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HENRY HORNER, Governor

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HON. HENRY HORNER, *Governor*

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TRANSACTIONS OF THE ILLINOIS STATE ACADEMY OF SCIENCE

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PAPERS IN AGRICULTURE

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Agriculture Section consisted of a symposium of seven papers on the general topic, "Problems of Seed Production in Illinois."

All but the following paper are represented herein.

"Production of Hybrid Seed Corn," by Earl G. Sieveking.

The group expressed a preference for the symposium type of program. Attendance at the meeting averaged about twenty-five.

Dr. James R. Holbert, Senior Agronomist of the United States Department of the Interior, Bloomington, Illinois, was elected chairman of the section for the year 1935-36.

(Signed) H. W. MUMFORD, *Chairman*

Physiology of Seed Germination

C. F. Hottes
University of Illinois, Urbana, Illinois

ABSTRACT

The subject of seed germination is one of perennial interest to agriculturists and botanists alike. An awakening interest in recent years has added much to our knowledge of the intricacies of the physiologic processes upon which germination depends, and has extended our understanding of seed maturing, injury, storage, and treatment to such an extent that certain principles of practice have become universal. But with all this progress many of the crucial problems of seed storage, seed bed preparation, effect of climatic factors before and after seeding, seed treatment on yield, etc., are still unsolved. The investigations of the future can most appreciably be advanced by a deeper study of the reactions of the living protoplast to external and to internal conditions.

We must recognize the seed as a highly specialized structure whose partially developed plantlet is held dormant by mechanical and biological factors. It is a knowledge of these factors and their effects on germination that has recently added so much of enduring value to applied plant science. A more intimate appreciation of the complex manner in which the living substance, through internal adjustment meets the diverse factors of the environment, is, and must be, our goal. The fact that the same factor acting at different times has a vastly different effect on the germination process, clearly indicates that the physiological phases of the protoplast must receive more consideration.

Canada Thistles in Illinois

Joseph E. Barnes
Illinois State Seed Laboratory, Springfield, Illinois

ABSTRACT

The United States Chamber of Commerce reports that the combined losses due to insect pests and plant diseases in the field are less than those caused by weeds alone. So, in Illinois seed production is inseparably related to the Canadian thistle problem and this is the season of the year for people to become weed conscious and plan for a more concentrated attack on the worst field weed in our State.

A year's survey, based on reports submitted by thistle commissioners throughout the state, shows there are today in Illinois 100,000 acres of Canadian thistles, the equivalent of four and one-half townships, approximately 156.4 square miles. Laid end to end they would reach from Bloomington to St. Louis.

The thistles are scattered over fifty-six of our best farming counties in patches varying in size from a rod square to 120 acres. The average size of patches in the industrial counties is 15 acres compared to one acre in the rural counties.

Consider some of the reasons for the widespread occurrence of the pest. Illinois people definitely are not weed conscious and have considered this weed a minor problem.

Of the fifty-six counties reporting last year, ten of the largest and most populous contained more than three times the acreage of thistles reported by remaining counties. In these ten counties fifty-five per cent of the land was farmed by the resident owner and forty-five per cent by tenants. The spirit of cooperation was poorer among owners than tenants.

The spread of Canadian thistles in seven of the ten counties has been influenced by the fact that much land there is owned by non-resident groups and, consequently, the system of agriculture is different.

Administration of the thistle problem has been at fault for the local authorities have not complied with the provisions of the law. In fact, fifty-two per cent of the local commissioners did not report on the situation in their communities. The local boards of supervisors failed to appoint commissioners of high calibre.

Administration officers are elective and many fail to enforce the law if their chances for re-election are endangered. So, local authorities defeat any attempt that may be made for an honest, efficient control of their own problems.

Mail order seed is another source of dissemination of Canadian thistles. Farmers who were attracted by price quotations to purchase such seed cause much damage in their community. "Back-fence trading" and buying from "fly by night" truckers hasten the spread of this weed.

In our haste to increase production we have forgotten a tenet of agriculture; namely, that a well-cared for acre yields as much as two that are poorly farmed. Our crops are gently nurtured plants that cannot, as a rule, withstand the savage competition of thistles.

The present methods for control measures are hopelessly inadequate to cope with this existing situation. May I in closing, mention some constructive ideas which if adopted and used persistently, will successfully destroy thistles and reclaim much good farm land that has become of marginal value in the last 25 years.

(1) Develop a long time program for weed control that will be consistently maintained.

(2) Under this program provide educational information free to the public. Establish demonstration plots in each township to be controlled by the township.

(3) Adopt a centralized planting committee manned by energetic, intelligent men to regulate control.

(4) Revision of the law so that the weed control program may be maintained and individual recalcitrants handled so that their weeds are taken care of and charged to their tax bill.

(5) Align the State's Attorney's Association so that they will adopt a definite stand and really support local officers in their control plans.

(6) Appoint weed commissioners for a term of 4 years so that they will be able to know the individual history of each case and really be able to plan adequately to care for each case. Appoint only capable men to this position.

(7) Solicit co-operation of owners of all farms, railroads, airports, sub-divisions, golf courses and resorts to cooperate in the program.

(8) Exercise the section of the law, condemning bringing in seed having noxious weed seed in it from out of State, making it a criminal offense.

(9) Inclusion of a course on weeds and weed control at all State schools and the University, making it a prerequisite.

(10) Provide for research on the ecologic and bionomic importance of weeds.

(11) Adopt the county committee plan as has been done in Boone County wherein the noxious weed committee handles all cases where the Commissioner is unable to secure co-operation.

(12) Maintain a weed council whereby the Farm Bureaus, the University, seedsmen, farmers and the State may convene to attack and solve the weed problems.

Effect of Seed Coat Injury on Germination, Vigor, and Yield of Corn

Benjamin Koehler
University of Illinois, Urbana, Illinois

Within the last twenty years, it has been determined by experiments conducted by a number of investigators that by selecting a corn type somewhat smoother in indentation of kernel and with a higher proportion of horny endosperm than the prevailing types, improvement could be made in field stand and vigor of plants, as well as in yield and quality of grain produced. There seems to be general agreement that a relatively horny endosperm is an important factor in increasing resistance to certain ear rots and checking some important seedling diseases. There remains a question in the minds of many, however, as to whether the type of kernel indentation has anythings to do with the matter.

Corn ears that feel rough to the hand have the seed coats of the kernels puckered into sharp ridges at the crowns. These ridges are frail, and in ordinary handling of the ears, the seed coat becomes broken on many kernels. In fully matured smooth types of corn, seed coat injury from reasonable handling does not take place at all.

In an investigation of this subject, data were collected on seed coat injury in the seed planted by a group of 200 Illinois farmers. These samples had been collected at random for another purpose at corn planting time. As an average of all 200 samples, 9.7 per cent of the kernels had the seed coat broken at the crown. The 10 samples with most injury averaged 26.4 per cent breakage, while the 10 best samples averaged only 0.6 per cent.

Previous experiments on the effect of seed coat injury in corn used for seed were few in number, and the results were not all in agreement. Certain experiments were therefore organized by the writer to obtain better information on the effect of seed coat injury in planted seed on the resulting crop.

A considerable number of ears of corn were used in the tests conducted for two years. The kernels were counted so that each ear was represented equally in each plot. Some of the kernels from each ear were injured. Injuries included shaving off the whole crown surface, removing one-fourth of the crown surface, puncturing the seed coat at the crown with a sharp awl, removing a little of the seed coat from the side where only horny endosperm was exposed, and removing the tip cap where the kenel is attached to the cob, thus exposing the dark tissue which covers the germ, but not exposing the germ itself. The remaining kernels from each ear were used as an uninjured check. Forty hills, planted three kernels per hill, constituted a plot, and there were nine replications in each experiment. Growing conditions in both seasons were unusual. In 1933 the soil was exceptionally wet at planting time, but became excessively dry during the summer. In 1934 the soil was barely damp enough for germination at planting time and drought continued until mid-summer. One would expect seed coat injury to be a factor primarily in the seedling stage. Although moisture conditions at planting time were very different in the two years, the results were similar (Table 1).

Seed coat injury at the crown of the kernels caused a significant reduction in yield in each case, even though the seed coat was only punctured. The reduction in yield was brought about by a reduction in stand and also a reduction in the vigor of the growing plants. Where the seed coat was removed from the whole crown, the reduction in stand, resulting from this injury, was 8.6 per cent, the reduction in height of plants when the plants were about waist high was 5.9 per cent, and the average reduction in yield of grain at harvest time was 20.7 per cent.

When the seed coat was removed from a small area on the sides of the kernels where only horny endosperm was exposed, the plants seemed to grow normally. No significant reduction in stand or yield was found. Removal of the tip cap may possibly have had a slight detrimental effect on the crop grown from kernels treated in such manner, but these tests so far have not settled this point, for the reductions found were not statistically significant.

The above results were obtained by planting unsterilized kernels in ordinary dark corn-belt soil in a rotation growing corn twice in every four years. In the same tests some of the seed was disinfected with ethyl mercury phosphate. This is a dry dust that stays on the surface of the kernels and protects the kernels at least to some extent from infection in the soil. Seed with injured seed coats treated with this disinfectant gave results nearly equal to those from uninjured seed (Table 1).

TABLE 1—EFFECT OF SEED COAT INJURY ON THE YIELD OF DENT CORN
Illinois Agricultural Experiment Station, Urbana.

Nature of seed coat injury	1933		1934	
	Acre yield	Reduction in yield from injury	Acre yield	Reduction in yield from injury
Seed Not Disinfected				
	Bushel	*Per cent*	*Bushel*	*Per cent*
None	50.8		49.4	
Whole crown removed	39.0	23.2*	40.4	18.2*
One-fourth crown removed	46.5	8.5*	41.0	17.0*
Crown punctured	44.5	12.4*	41.5	16.0*
Tip cap broken off	48.8	3.9	48.5	1.8
Cut in side of kernel			48.9	1.0
Seed Disinfected With Ethyl Mercury Phosphate				
None	50.5	0.6	48.2	2.4
Whole crown removed	50.0	1.6	49.2	0.4
One-fourth crown removed	47.8	6.0	48.9	1.0

* Odds of probability greater than 30 to 1 that the reduction is significant.

The soil is inhabited by a great number of microorganisms and the nature of this population is influenced by many factors. Therefore, it would not be surprising if the results obtained from planting crown-injured corn at different times and places might give various results. Fungus isolations were made from the internal tissues of injured kernels several weeks after planting. Various Penicillia were especially abundant in these isolations, and frequently *Penicillium oxalicum* was recognized. Inoculations were made on injured seed with pure cultures of a number of fungi just before the seed was planted. These inoculation tests were made in the greenhouse and also in the field. *Penicillium oxalicum* caused very severe stunting and seedling

blight, regardless of whether the inoculated corn kernels were planted in wet, intermediate, or dry soil. Other Penicillia investigated so far were nearly harmless. *Aspergillus flavus* and *Aspergillus tamarii* gave a striking effect, except in dry soil, in that they produced virescent plants (plants partly white or cream color). *Gibberella saubinetii*, on the other hand, caused severe stunting and seedling blight only in dry soil. From results so far obtained in these tests, it seems logical to conclude that *Penicillium oxalicum* is an important cause of the harmful effects observed from planting corn with the seed coat injured at the crown, but it is likely that some other organisms may also be of importance.

Conclusions.—Rough-eared seed corn is easily injured in handling, and kernels having seed coats injured at the crown, when planted, are much more severely injured by a number of fungi than kernels with sound seed coats. This, no doubt, was one of the important factors involved when in earlier work it was found that the field performance from rough ears was not usually so good as from smoother ears. With the development of good corn-seed disinfectants in recent years, the harmful effects from seed coat injury can largely be eliminated.

The Purity of Illinois Seed Stocks as Revealed by Seed Analysis Studies

L. A. Moore

Superintendent, Division of Plant Industry, Department of Agriculture, State of Illinois

The Illinois Law on agricultural seeds applies to the seeds of small seeded legumes, grasses, rape and seed corn. Little attention has been given to seed corn because of the limited facilities of the laboratory. This discussion is limited to the seeds of our common meadow and pasture crops.

Between July 1, 1934 and April 23, 1935, the Illinois Seed Testing Laboratory analyzed 7,828 samples of seeds used in meadows and pastures. Of this number 1,045 samples or 13.2 per cent were unsalable for seeding purposes in Illinois. Section 5 of the Illinois Seed Law states that: "It shall be unlawful to sell, offer or expose for sale for seeding purposes within the State of Illinois any agricultural seeds or mixtures of same containing Canada thistle in greater numbers in the aggregate than one to fifty grams; quack gass, dodder, wild mustard, wild carrot, buckhorn, dock, field sorrel, ox-eye daisy or Johnson grass, in greater numbers in the aggregate than the proportion of 1 to 1,000. Provided, however, that the proportion of field sorrel in alsike, timothy and white clover be not greater than 1 to 500."

To comply with section 2 of the law any container of agricultural seed must have a tag or label showing the approximate number per ounce of each kind of the seeds of the following named noxious weeds, except Canada thistle, which are present singly or collectively, as follows: (1) in excess of one seed in each five grams of red clover, mammoth clover, white clover alsike clover, sweet clover, alfalfa, lespedezas, timothy, blue grasses, brome grass, orchard grass, red top, fescues, oat grass and rye grasses; (2) one in twenty-five grams of rape, sudan grass and millets; (3) one in one hundred grams of vetches. Noxious weed seeds are defined as seeds of buckhorn, field sorrel, Canada thistle, quack grass, docks, ox-eye daisy, dodders, wild mustard, Johnson grass, wild carrot.

If this requirement is met, the law provides a very liberal tolerance. It allows the sale of seed containing nine Canada thistle seeds per pound in any kind of seeds. In this instance the limitation is expressed in weight. Other noxious weeds are tolerated in the ratio of one to one thousand. On this basis, the number of noxious weed seeds per pound varies. Alfalfa may contain 208 noxious weed seeds per pound, blue grass, 2,192, red top 3,372, timothy 1,216, red clover 304, sweet clover 368 and lespedeza 264. It is quite obvious that at the average rate of seeding for these crops from 2,000 to 33,000 weed seeds may be sown per acre and yet be within the law.

A further tolerance in favor of the dealer or seller of seeds is provided in section 2, paragraph d of the seed law; for example Canada thistles may be present in a smaller proportion than 1 to 50 grams or other seeds may contain as many as 96 noxious weed seeds per pound without the information being given on the tag. Seed that complies with the requirements of the Illinois Seed Law is not always pure seed. The law establishes

a maximum amount of weed seeds that may be present in seed to be sold for seeding purposes in Illinois. The analyses of all the samples of the principle crop seeds show a wide range of purity. The following table shows the total samples of each crop analyzed and the percentage unsalable:

	Total		Percentage unsalable
Red Clover	4,170		16.1
Sweet Clover	1,173		4.4
Alfalfa	786		5.3
Alsike	259		10.3
Timothy	753		15.4
Lespedeza	747		18.3
Total	7,888	Av.	13.2

The percentage of unsalable samples per year varied from 9.9 per cent to 15 per cent with an average of 11.7 per cent for the last 7 years. Seasonal effects on the quality of the seed and weed growth may account for the variation. With the great improvement in seed cleaning machinery and its distribution throughout the State, an improvement in the quality of seed is anticipated.

There are three sources of seed supply for Illinois purchasers. First, the producer, second the Illinois seed dealer, and third the seed dealer outside of the State of Illinois, chiefly mail order houses. Section 12 of the Illinois Seed Law specifies that only samples of recleaned seed may be submitted to the laboratory for purity analysis. Consequently the analyses made by the laboratory are of samples purported to represent seed which has been cleaned. It is well known that many farmers and some dealers do not take cognizance of the seed law. Many illicit sales have been made. Very frequently such sales are discovered by inspectors who take official samples and submit them to the laboratory for analysis. These are designated as inspector's samples and 35 per cent of them have been unsalable. The total number of sales of this nature is hard to estimate, but we can say that seed from this source is usually of inferior quality due to the presence of weed seeds and inert matter. Recently a sample of alfalfa representing such a sale showed 27 per cent weed seeds and 4 per cent inert matter. It is interesting to note that in this instance there are no noxious weed seeds present. Many other examples may be given to convince one that this source of seed is unreliable.

Since the service of the Illinois Seed Laboratory is furnished free of charge, we feel that a producer or dealer who sells seed without a proper analysis shows lack of responsibility to agriculture and contempt for the seed law, consequently a number of prosecutions have been made during the past season.

Producers especially in Northern and Central Illinois have been making use of the seed testing laboratory in increasing numbers. Of all farmers' samples submitted during the past year, 13.6 per cent were unsalable compared to 6.9 per cent of all samples submitted by recognized wholesalers in Illinois and 2.9 per cent for out of state dealers.

The unfavorable showing of the Illinois dealers when compared to dealers from other states is due to the fact that many Illinois wholesalers submit samples of farm-cleaned seed for analysis before purchasing from the producer. While some dealers from other states have supplied only seed of high quality, the "out of state" dealers are the principle source of low quality seed so far as the records of the laboratory reveal. For example, the supply of one mail order house is represented by 15 mixtures, all containing noxious weed seeds, with seven of them unsalable; 12 samples of alfalfa with 10 containing noxious weed seeds and 2 unsalable. The average germination of the alfalfa was 55 per cent; of sweet clover 48 per cent

with the other crops running from 15 to 30 per cent below standard. The average germination on all seeds from Illinois dealers is 93 per cent and of all Illinois farmers' samples 86 per cent. Of 22 lots of alfalfa taken from Illinois wholesale dealers none were unsalable; 4 showed the presence of noxious weed seeds and the average germination was 80.5 per cent. Of 10 lots of sweet clover, none were unsalable, 3 contained noxious weeds and the average germination was 83 per cent.

To give briefly, an idea of the purity of seed stocks in Illinois the following table is presented—100 salable samples of each crop taken at random are considered:

TABLE 1

	Per cent purity	Percent weed seeds by weight	Per cent inert	No. of samp. containing noxious weeds
Red Clover	97.69	.50	1.33	50
Sweet Clover	97.4	.56	1.8	24
Alfalfa	98.0	.51	.93	21
Timothy	98.0	.41	1.12	66
Lespedeza	97.58	1.18	1.15	53
Alsike	97.01	.25	2.05	40

From the data submitted, it appears that wholesalers equipped with modern seed cleaning machinery are the best source of seed supply. However, farmers who avail themselves of good custom cleaning facilities may supply seed of high quality. Without question the mail order house supplies seed of lowest quality.

The production of high quality seed is largely a matter of weed control and it is important that Illinois become weed conscious.

Sweet Clover Seed Production

Walter A. Newlin
Casey Township High School, Casey, Illinois

The production of sweet clover seed in Clark County began in 1921 by a farmer who harvested 13 acres with a grain binder after it had been pastured rather heavily with cattle. The field made 25 bushels which sold for eight dollars per bushel. The same method tried in fields that had not been pastured with live stock grew so rank that a binder could not handle it. A demand for home grown seed brought a study of other methods of harvesting the seed.

Since the seed shatters easily, forms of beater type machines were developed. The first one, built by a farmer, was a large box on which was attached a reel that was driven by a chain from the drive wheel of the tractor. It was successful but expensive to build and could be operated only with tractors. Another beater made to push ahead of horses proved impractical. In 1924 the vocational agriculture department of the Casey Township High School constructed the binder type beater which can be drawn by horses or tractor. This machine was made on the frame of a discarded 6-foot binder. It beats the seed into a cage and drags the plants down to be plowed under for fertilizer. The cost of construction varies from thirty to fifty dollars.

The time to harvest sweet clover seed with a beater type machine is when the greatest amount of ripe seed is found on the plants. This is hard to determine since the seed does not always ripen evenly. Too early harvesting gives much green seed of poor quality, yet waiting for more to ripen permits some of the earlier plumper seed to be shattered. The seed is beaten onto an enclosed platform and is removed from the harvester at one end of the field through a door at the rear of the machine into a large flat box where it is run through ¼-inch hardware cloth into a wagon box to remove the coarser trash and leaves. The seed should be spread on a floor to a depth of not more than 6 to 10 inches, depending upon the amount of green material, and should dry for two weeks when it may be bunched or cleaned with a fanning mill and hulled if desired. Very little seed is hulled now except that sold to seed dealers.

Sweet clover seed that is to be hulled and scarified is usually run through a machine which blows the seed against sand paper. Regular threshing machines and Letz feed grinders are sometimes used. One hundred pounds of good clean seed in the hull will make from 70 to 75 pounds of seed when hulled, depending upon the quality.

The yield of seed varies with weather conditions and types of soil. Our largest yield was eight bushels of scarified seed per acre in 1926 from a 5-acre patch. Other yields have varied from nothing to 5 bushels, and the average is about 2 to 4 bushels. We have never determined the amount of seed that is shattered on the ground by harvesting, but when followed by wheat a fine stand of volunteer clover is obtained.

Only the large white blossom biennial is grown in our section where it is true to type and generally free from disease. Other varieties have not given satisfactory results. We need a strain of the large white blossom

biennial which will mature at least a month later than it does at present, providing a pasture period for live stock through the driest part of the season when it is most needed.

The vitality of the seed deteriorates after it is hulled and scarified, depending upon the severity of scarification. Seed three years old has turned a reddish-brown and when sown in the field gives a poor stand. The unhulled seed retains its vitality much longer, as shown by germination tests made on seed that was ten years old when hulled and scarified. When all our seed came from the northwest, only hulled and scarified seed was sown because the seed coat was so hard that moisture could not penetrate and very poor stands resulted from unhulled seed. About 1925 farmers began seeding unhulled seed with winter wheat during the last of February and the first of March at the rate of 15 pounds per acre, obtaining good stands, but hulled and scarified seed sown in wheat at the same time germinated more readily and was frozen. Sowing unhulled seed with oats after all freezing and thawing is over is being practiced by more than half the farmers of our community with good results. It may be that after being grown under our more humid conditions the plant has become acclimated to such an extent that the seed coat is softer than on seed produced in the northwest.

Types of soil and weather conditions play an important part in the production of sweet clover seed. Clover fields which ripen evenly and hold the seed always produce the best yields even if the stands are not so good. Clover with these characteristics is usually found on the poorer type of soil, as gray silt loam. In fields with good brown silt loam soil you will find good stands with ripe seed, green seed, and bloom all on the same plant, so that there is never a time when seed can be harvested. The product is either of poor quality large red seed which is worthless or immature seed which will not grow.

Weather is important. A day of strong wind when a field is ripe may shatter the seed so badly that it is not worth beating off. Rains ten days to two weeks before the seed begins to ripen (on clover grown on gray silt loam), cause the plants to start reblooming and the seed aborts as it ripens. Rainy seasons give the same results.

In conclusion it may be said that sweet clover seed can be produced economically when grown on gray silt loam provided there are no heavy rains ten days before the seed ripens and no strong winds at harvest time. The seed should be harvested with a binder type beater. One of the greatest benefits that can come to a live stock producer is for some one to develop a strain of sweet clover which will mature one month later than our large white blossom biennial matures at the present time.

Insects in Relation to Production of Red Clover Seed

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In preparing the following manuscript the author has in mind that the only consideration to be dealt with is the production of seed of red clover. The factors considered, their effect on the plant, and recommendations offered are based entirely on that premise. The suggestions do not in all cases agree with those that would be made where red clover is used as a hay and fertility-maintenance crop.

Red clover is attacked by insects at various stages of growth and almost continually during its entire life. The production of seed by the plant is affected either directly or indirectly in several ways and several factors influencing the development of a good crop of seed are affected.

EFFECT OF INSECTS ON STAND

One of the primary requisites for a satisfactory seed crop is, of course, the development of a good stand of plants in the field. This may be affected by insects at two times.

Leafhoppers.—First, during the seedling stage and the remainder of its first season of growth red clover is attacked by the Potato Leafhopper, *Empoasca fabae* Harris. The amount of damage done by this insect can and does determine whether or not the crop will survive to produce any growth at all, or whether the growth that does survive will be strong and healthy. The plant is also affected during the second year of growth, soon after the first cutting, at which time the leaves are affected by so-called 'tip-burn' or 'yellows'. The damage may develop to the extent of practical destruction of the plant.

Prior to 1927 this was considered a physiological condition. At that time it was found that this condition was directly caused by the Potato Leafhopper mentioned above. Research demonstrated that foreign clovers were unable to survive the attacks of these insects, but that native strains of red clovers could survive under most field conditions. This work has been previously reported.[1]

The use of native strains of red clover seed will largely prevent serious losses from this cause.

Clover Leaf Weevil.—During the fall and winter of its first season and the spring of the second season red clover is attacked by the larvae of the Clover Leaf Weevil, *Hypera punctata* Fab. The adults of this insect deposit their eggs in the mature, hollow stems of the clover plant during September. A portion of the eggs hatch during the fall, while the remainder stay in the stems until the following spring before hatching. Those larvae which have hatched spend the winter in the trash under the plants.

[1] Hollowell, E. A., Monteith, John Jr., and Flint, W. P., Leafhopper injury to clover. Phytopath. 17, 6, 399-404, June, 1927.

The losses are caused by the feeding of the larvae on the leaves. The larvae are small, green, footless worms with a white or yellowish stripe down the back. They feed during the nights or on dark, cloudy days. During the day they are usually found curled up in the base of the plant or in the trash under the plant.

During long, cool springs the damage by the insects is frequently so severe as to cause total destruction and death of the plants. In 1927 hundreds of acres of red clover were plowed under because of this condition.

Farmers have found that much of this damage may be prevented by burning over the stubble during the winter. If this is done while the plants are fully dormant they survive this treatment, but if they have started to grow they will be killed by it. Spraying of the plants with an arsenical poison would produce control, but is not economical under present conditions. The insects are frequently controlled by a fungus disease which will develop on them during warm, wet weather. This is the most common check to an outbreak.

Clovers other than red clover do not suffer as badly as this crop, especially in mixtures.

EFFECT OF INSECTS ON THE NUMBER OF BLOOMS

Another essential to the production of seed is the development of a large number of heads in which the seed may be produced. This depends, of course, on the general condition of the plants and is indirectly affected by the Clover Leaf Weevil as described above. It is also directly affected by the Lesser Clover Leaf Weevil, *Phytonomus nigrirostris* Fab.

Lesser Clover Leaf Weevil.—The adults of this insect are small (about ⅛ inch long) snout beetles covered with green hairs so that it appears green to casual observation. The adult spends the winter in trash in hedgerows, fence rows and, to a certain extent, in the trash under clover plants in the field.

The eggs of the insect are deposited in the inter-epidermal layer of the stems during mid-April to mid-May and hatch in 2-3 weeks into footless, maggot-like worms, whitish in color, with a black head and a black or brown line across just behind the head. When taken from the plant they lie in a crescent shape in the hand.

Much of the feeding of these insects is done in the axils of the leaves and stems. They burrow into the stem just below where the bloom is forming and either cut off the stem or entirely devour the newly-formed bloom before it develops beyond the leaf-axil.

The importance of the insect may be shown by the results of a single survey trip June 3-4, 1929 in western Illinois where it was found that 17.3 per cent of the stems and 58.2 per cent of the blooms were infested, and 33.6 per cent of the blooms were completely destroyed. Other and similar observations could be quoted from other years, the infestation varying, of course, from season to season.

Much of the damage can be avoided by delaying the development period of the clover by pasturing lightly until about May 1st. Some benefit should be obtained by destroying the adults in the winter by cleaning up the hedges and fence rows and burning the stubble.

EFFECT OF INSECTS ON CONDITION OF BLOOM

After the clover blooms have developed it is essential that they remain intact if they are going to produce a satisfactory crop of seed. The Clover Head Caterpillar, *Grapholitha interstinctana* Clem., attacks the plant in this stage.

Clover Head Caterpillar.—This insect attacks the red clover plants both fall and spring. In the fall they feed in the crowns of the plants, reducing the vitality of the plants so that they are not able to withstand winter as well as they might, and this is important. But the greatest damage as a red clover seed pest is the feeding on the blooms in the spring and summer.

There are three generations of the insect. The fall larvae hibernate and produce moths in the spring which lay eggs at the base of the developing florets. The larvae from these feed in the flowers at the base of the florets and cut them off, thus destroying their ability to produce seed. The adults of these develop in time to attack the normal second crop of red clover heads and damage them, and the third brood of adults appear in time to produce the over-wintering larvae in late blooms in the fall or on tender shoots at the base of the plants.

The importance of this insect is indicated by survey figures. For instance, in 1923 in western Illinois 33 per cent of the first crop blooms were attacked. In 1924 as high as 86 per cent of the heads were infested. In 1926 54-70 per cent showed damage, and 23 per cent were infested in 1928. Certain counts showed that about 7 per cent of the infested heads are completely destroyed.

Certain important records were made in 1927. In that year first crop clover showed 1.5-2.7 per cent of infested heads, but second crop clover developed 17.2-23.6 per cent infested heads on several counts. The damage that year was light but the increase between the first and second crop infestations is rather spectacular.

It is not supposed that all losses caused by this insect can be averted, but they may be reduced by: (1) Destroying the over-wintering generation by fall clipping and removing volunteer crops by plowing clover fields in the fall; (2) delaying the development of blooms in the spring by clipping or pasturing; (3) the use of first crop clover for the seed crop and avoiding the heavy second brood damage.

DIRECT EFFECT OF INSECTS ON SEED

Finally, the seed produced must be plump, healthy, mature seed. Two insects may be responsible for the destruction of the seed of red clover after or just as it is being formed, namely, the Clover Seed Chalcid, *Bruchophagus funebris* How., and the Clover Seed Midge, *Dasyneura leguminicola* Lint.

Clover Seed Chalcid.—The adult of the Clover Seed Chalcid is a small, black, four-winged fly to be seen about the maturing heads of red clover. There are at least three broods of the insect occurring on the first crop, second crop, and volunteer heads of the fall crop. The generations are not distinct.

The damage is done by a tiny, white, footless maggot which lives inside the seed, causing a total loss of each seed so infested. The seed is very light or broken and only the hull is left. These are blown out by the fan in threshing and constitute a large part of the seeds which go into the straw pile and cause the farmer to think that he is getting 'a poor job of threshing'.

Losses from this insect vary greatly from year to year, but may be very serious. Records show infestation, and consequent loss of 18.8 per cent of the seed in 1925, 12-15 per cent in 1927, and 16.6 per cent in 1928. These are estimated to cause a reduction in yield of approximately a peck an acre, and are for first crop clover. Second crop records are not available, but it is observed to be more severe than the first crop.

These losses cannot be entirely eliminated, but certain practices will be of benefit: (1) The use of the first crop for seed will avoid the heavy second brood damage; (2) clipping or pasturing in the fall to remove the overwintering population will reduce the number present the following spring; (3) destroying the straw stacks into which much of the infested seed is blown will remove that many.

Clover Seed Midge.—The Clover Seed Midge is much like the Chalcid except that it attacks the ovules before the seed is entirely formed. Their presence in the field is indicated by flowers that are partly in bloom and partly green where development has been stopped. Infestation at Urbana has been reported by Mr. Flint as high as 25 per cent.

Infestations are more severe in the second crop clover than the first crop. The appearance of the adults coincides with the development of blooms in the clover so that the broods come along with each crop of clover.

The application of remedies for the Clover Seed Chalcid will help reduce damage by the Midge.

SUMMARY

The grower whose aim is to produce a maximum of red clover seed cannot afford to neglect the importance of insects affecting the crop.

Clover is attacked in all stages by insects that affect the seed production indirectly or directly by influencing (1) the condition of the stand; (2) the production of an abundance of blooms; (3) the development of well-rounded, full blooms; and (4) the production of an abundance of plump, mature seed.

The maximum results in controlling these insects may be expected by following the following practices:

(1) The use of native strains of seed.
(2) Fall clipping or pasturing.
(3) Winter burning when the plant is fully dormant.
(4) Pasturing lightly in the spring until about May 1st.
(5) Cleaning up fence rows and volunteer growths in the fall.
(6) Disposing of old straw stacks.
(7) The use of the first crop for seed.

PAPERS IN ANTHROPOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The entire program consisting of eight papers was presented before the members and guests of the Anthropology Section.

It was suggested that the Central Section of the American Anthropological Association, of which George R. Fox, Dowagiac, Michigan, is Secretary, be invited to meet with the Anthropology Section of the Illinois State Academy of Science.

Attendance at the meeting averaged twenty-five and maximum attendance was thirty-six.

Dr. J. B. Ruyle, Champaign, Illinois, was elected chairman for 1935-36.

(Signed) BRUCE W. MERWIN, *Chairman*

A New Type of Burial Mound Near Quincy, Illinois

O. D. Thurber

Quincy Senior High School, Quincy, Illinois

There are dozens of early burial mounds in west central Illinois along the Mississippi River. In Quincy, one of the parks has six mounds, and an expedition from the University of Chicago spent the summer of 1928 excavating in and near another park. Mounds are scattered for at least 75 miles along the river north and south of Quincy.

Most of them are the typical mounds of western and southern Illinois, but the type of mound here described is entirely different. The site is eight miles down the river from Quincy in the bottomland immediately adjacent to what is known as the bottom road. The burials are on slightly sloping ground about 200 feet from the foot of the bluff and two miles from the river. The immediate place of burial is approximately 120 feet by 80 feet and roughly rectangular. It is only slightly raised above the surrounding ground.

The first crypt or vault was badly destroyed before its contents were fully discovered. Eight burial vaults were found in the west half of the mound, which is all that has been excavated to date. From five to thirty-five individuals were buried in each crypt. After the discovery of twenty-eight individuals in the second crypt, the University of Chicago was notified and Dr. Newmann arrived to take charge of the work.

The crypts varied in depth, the average being two feet. They were roughly circular and rectangular in shape with an average diameter of about six feet. All of the vaults were built of native limestone slabs laid up in a more or less regular brick masonry formation with the inside wall vertical. The tops of the walls were from two to three feet thick and the bases from four to six feet thick. Each crypt was covered with layers of flat rocks laid regularly to form a rock cover a foot or more thick. One vault near the middle along the west side of the group that was opened had a doorway that faced southwest. A six-foot stairway with laid-up walls led down to the crypt floor. The three steps were formed by flat rocks laid on the dirt.

The earth was removed from the outside of all these crypts before any of the rocks were removed, then the cover rocks were taken off and the material taken from the inside. The contents of these stone vaults are more difficult to describe exactly. Broken pieces of pottery were found everywhere, both inside and outside the crypts, almost all of which were shell-tempered and fire-blackened on the inside. Everything was badly jumbled, yet bones seemed to lie in layers. On the bottom was a layer four to eight inches thick of unburned bones, more or less in their proper relationship to each other, with the bones of several individuals piled together. In some instances a few small flat rocks seemed to separate this layer and the next one. The second layer consisted of charred bones and bone fragments. In only one instance were they completely matted with charcoal and ashes, yet single pieces of charcoal and bone fragments were found scattered

throughout every crypt in all the layers. The third layer was for the most part unburned bones and fragments. The top layer was a mixture of both burned and unburned bones. These are called layers for want of a better term, but they were not separate, distinct, layers, as each seemed to fuse into the next.

In one vault seven skulls were found, fairly free from breakage, piled in one corner. The number of individuals represented in these crypts could be computed only by counting the skulls. In the eight crypts so far uncovered we have found 152 skulls, only one of which, a woman's, was in perfect condition.

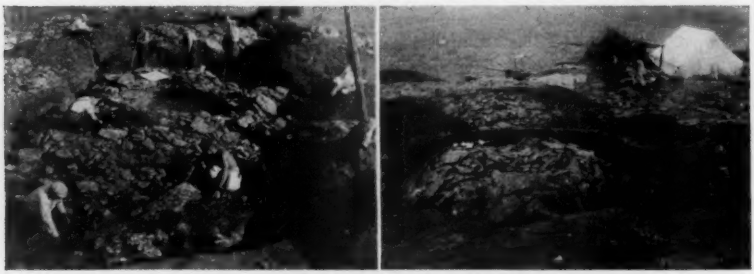

Fig. 1.—Vault graves near Quincy, Illinois.

Five pipes were found. One was an unfinished effigy stone pipe, two were shell-tempered pottery pipes, and the other two were stone, one of which was highly polished, of delicate construction, and showed much use. Only four small projectile points were found, four bone needles, three stone knives, one small scraper, and only two pots. One was an ordinary shell-tempered eight-inch pot and the other was a little two-inch pot about three-fourths full of what appeared to be face or body paint. Three beads made from the columella of sea shells were found.

Obviously these burials were a type of bundle burial, possibly extending over a period of many years. It is almost certain that most of the bones were devoid of flesh when they were interred. It is quite likely that part of the creamation was done in the vaults, but most of it was done elsewhere and the charred bone fragments carried in for burial. The bones of men, women, and children were jumbled together as if they had been tossed in from outside the pit.

The age of this site is problematical, yet all indications are that it is several hundred yeaus old. Who were these people? We do not know and can draw definite conclusions only after other similar sites have been discovered and excavated. The writer knows of one other such site near Quincy and hopes to help get more exact information from it.

A Method of Restoration of Indian Mounds

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ABSTRACT

Mounds may be preserved in their present state or restored to their original contour by calculating the equation of the curve of the mound. This can be done by certain primary excavations made in the most advantageous places. The procedure would be to excavate near the toe of the mound on either side until the top of the original mound is uncovered. This line is usually easy to place as the difference in the soil above and the mottled appearance of the mound itself is very evident. If the point where this top line intersects the original base of the mound is found, so much the better. If this point is not found, however, it will be necessary to calculate it from the slope of the top and the base line as found, or estimated. Readings should then be taken on the top slope of the original mound and tabulated for elevation above the base of the mound and distance, at right angles, from the center line or axis of the mound. Thus 68'/4.5 would mean that 68 feet from the axis the top of the mound was 4.5 feet above the old base.

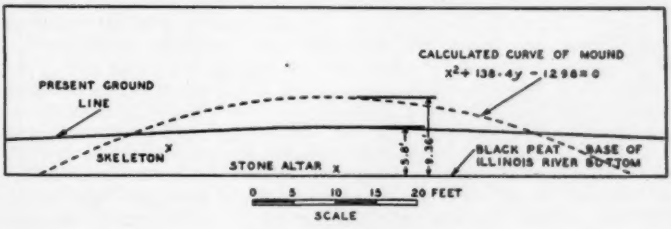

Fig. 1.

The equation of the curve of most mounds will be of the form, $Ax^2 + By - C = 0$, where A, B, and C are constants for any particular cross-section of a mound. By taking measurements from the true axis of the mound the value of "A" in the equation will be 1. The value of "C" is easily determined by finding the point where the top slope of the mound intersects the old base. Then y will be zero and "C" will equal x^2. To determine the value of the constant B several elevations should be taken and referred to the axis, and these values of "x" and "y" substituted in the formula and the average of the value thus found used as the true value of "B".

The procedure may be illustrated by an example: In the excavation of a certain mound, the original toes of the mound were found to be 36 feet either side of the axis. That is x was plus or minus thirty-six when y was zero (see Fig. 1). Substituting 36 and 0 for x and y in the equation we find C is 1296. Then, by elevations taken on the mound, it was found that

28 feet from the center the original mound was 4.4 feet above the old base. Substituting these values of "x" and "y" in the equation we find B is 138.4. Thus the equation for the curve of the mound becomes $x^2 + 138.4y - 1296 = 0$. At several places where the top of the old mound could be seen this equation was checked and found to be correct in every instance.

This method is valuable because where time, the elements, and man have partially destroyed a mound it can be restored to its original form by calculating this curve. The mound shown in Fig. 1 had been under cultivation for a number of years and had been almost obliterated. To restore it to its original shape it was only necessary to rebuild to the curve $x^2 + 138.4y - 1296' = 0$. The mound was but 5.8 feet high due to cultivation. By letting $x = 0$ in the equation and solving for y we found the original height of the mound was 9.36 feet. Let it be emphasized that comparatively few elevations are necessary and very little excavation need be done to make sufficient determinations to estimate what the original contour of the mound was, at the time it was built.

Our Debt to the Indian

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When the first textbook was published on the subject of American history, about the year 1775, a large proportionate amount of space was devoted to the American Indian. As time went on, less and less space was devoted to Indian history until about two decades ago, when we reached a point where this topic had been almost entirely dropped except for incidental mention.

In the latter part of the nineteenth century the authorities on the teaching of American History in the elementary and secondary schools, laid down the principle that in choosing the curriculum for these schools we should admit only such historical material as belonged to the stream of history to which we owe our civilization; namely, that flowing via Northern Africa, Western Asia, Greece, Rome and Western Europe. For the reason that he had not contributed to our lineage or our culture, the American Indian was to be dropped.

But there is coming into being a changing viewpoint as regards the function of the Indian in American history. From being accustomed to regard him as an extinguished enemy, of interest only as a museum specimen, many have come to consider him as an important factor, in the development of our modern culture.

The problem.—Suppose that Columbus had found the American continent a land never yet peopled by any race. What difference would that circumstance have made in the exploration and development of the country? What differences would be in our modern culture? Have the inventions, geographical knowledge, agriculture, and woodcraft of the Indian been a positive factor in attaining to our present stage of culture?

The North American continent.—The North American Continent is a region of vast distances. In a north and south direction, it stretches from the tropics to the arctics. Great mountain barriers rise close to the eastern coast. The greatest river system and the largest fresh water lakes to be found anywhere upon the face of the earth care for the drainage of the interior. The colonists had to confront the problem of an indigenous food supply. To face the problem of conquering so remote and so vast a continent entirely without intelligent guidance would have been the severest test of the stamina of any people.

Friend and guide.—The colonists who sought our shores were not trained in woodcraft, but came from various motives. Some were religious or political radicals who came to escape persecution; some were indentured servants; some were land speculators; some had been prisoners for debt; some were gold seekers. It was not a particularly well chosen group from which to select men to cope with the problems of the pioneer. How rapidly would such people have conquered these natural obstacles without the ready trained skill of the friendly aborigines? We must not forget, that in the majority of cases the success of the exploring expeditions was largely due to Indian guides. Their knowledge of the geography of the continent was acquired by long journeys or spying expeditions and by oral reports of other

tribes. The red man was not exactly a stay-at-home as the wars between the Iroquois and the Illini bear witness. In their century-long quest for a passage to the South Sea, the explorers of the eastern coast were told repeatedly of a great water to the west. From letters which reached England from Virginia in 1648 we learn that Indian rumors had already come to governor Berkeley concerning the land beyond the mountains, of the great river systems and of the Gulf of Mexico.

Indian guides made possible the marvelous chain of discovery by which the French linked the Gulf of St. Lawrence with the Gulf of Mexico. They made possible the discovery by the Virginians of the upper waters of the Ohio Valley and the basing of England's claim on the basis of prior discovery.

In 1687 LaSalle having failed in his effort to colonize Louisiana found himself in his last extremity of suffering and want. Failure to locate the mouth of the Mississippi, mutinies, shipwreck, hunger and disease defeated the great leader but could not break his iron will. With a party of seventeen men, using Indian guides, he set out overland for Quebec. Two months later he was murdered by mutineers from his own party on the banks of the Trinity. Indian guides, scouts and soldiers have fought side by side with the soldiers of the United Colonies and States in every War from the War of the Revolution to the World War.

Indian money a factor in New England civilization.—Another way in which the Indians of the coast contributed to the welfare of the colonists was by furnishing them with a currency; this stimulus was Indian wampum.

The unit of value first used among the natives was the cubit. It no doubt originated from the handy scheme of seizing the wampum belt in the knuckle of the little finger, running it down the forearm to the point of the elbow, and there seizing it as a mark. This mark was then lifted to the knuckle and the process repeated at will.

The debt of language and literature.—Twenty-four of our States bear Indian names. But it is not for geographical names alone that our language is indebted to the Indian. We use a large number of other words in our English-American speech whose Indian origin we never suspect. Tabulations show that we use about five hundred words of this kind, also many popular phrases and expressions are of Indian origin. Literature has been enriched by Indian legends and stories, such as Longfellow's "Hiawatha" and Alonzo de Ercilla's "La Araucana".

In time of war, officers of the opposing armies are constantly trying to devise cipher codes which will deceive each other. Yet during the World War the German intelligence officers captured many American messages which they could not decipher. After the close of the War the secret was let out. The American messages were written in the Choctaw Indian language —and the Germans did not know that such a language existed.

The debt of the arts and sciences.—To the Indians we owe our introduction to a knowledge of gums and resins, valuable timbers and many useful inventions.

Indian doctors taught the colonists the use of many valuable medicinal herbs and other members of the forest pharmacopeia.

The debt for a nation's food.—Before the coming of the white man the Indian had developed corn or maize into practically its present form. The effect corn had on colonial development, the westward movement, the live stock industry, the building of cities and railroads, in winning the Civil and World wars are topics too large to discuss in a paper of this length.

The conclusion as to the enormity of our debt to the Indian for friendly guidance, for pioneer currency, for useful inventions, our vocabulary, our knowledge of the arts and sciences, and for the nation's food supply is so obvious as to need no further proof.

Bannerstones and Related Ceremonial Objects From Southern Illinois

Irvin Peithman

The bannerstones and related ceremonial objects from southern Illinois here described are grouped according to four regions: first, the lower half of the Kaskaskia River; second, all of the Big Muddy River and its tributaries; third, the Mississippi Bottoms south of the mouth of Big Muddy; and fourth, Cypress Creek in Johnson and Union counties. The statements are based on trips made over the various village sites that are located on the above mentioned streams and on a study of collections of relics.

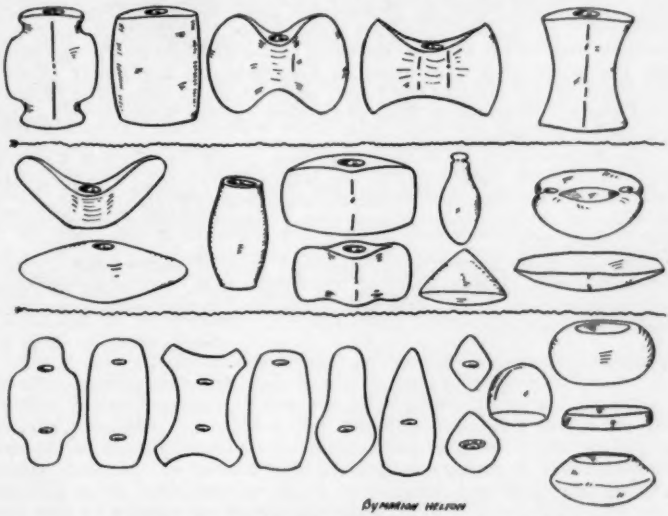

Fig. 1.—Artifacts from Big Muddy River and tributaries.

On the lower half of Kaskaskia River the predominating problematical forms that have been found on the village sites are the discoidal and plummet. These two types are well made and are above the average in size and symmetry. The bannerstone, gorget, and pendant are very scarce here and only several have been found in late years. In only rare instances have broken ceremonial objects been found in the debris of the various village sites.

Slightly to the southeast of Kaskaskia River lies Big Muddy River and its tributaries; Beaucoup Creek, little Muddy River, and Crab Orchard Creek. In ancient times these streams were more thickly populated as evidenced by the numerous large and small village sites. Along Beaucoup

Creek one finds a converging of all the problematical forms in larger numbers than in any other given area in southern Illinois.

All of the known types of ceremonial objects common to southern Illinois have been found on the Big Muddy River village sites. Here one finds many broken ones of which quite a few show that they have been reworked and some have repair holes drilled through them. The bannerstones are very interesting in that they show finish and symmetry of the very highest degree. The general type is somewhat tube-like with short wings and very closely resembles the types that are found in Kentucky and Tennessee. They have a slightly curved under side while the top has a very pronounced ridge extending the length of them. Quite a few unfinished ones have been found here. These are very interesting for they show in the unfinished hole a core made by a reed drill. The favorite material from which the various forms were manufactured was basalt, slate, quartzite, and hematite. The discoidals and plummets from the village sites on this stream are the same general type as those found in the Kaskaskia River area. The gorgets and pendants are found in more shapes here than in any other locality in southern Illinois. A few boatstones and cones have been found on different sites here but they are not common over the whole of southern Illinois.

The village sites along Mississippi River south of the mouth of Big Muddy River are fewer in number but much larger in size, the various problematical forms that have been found on the Big Muddy River sites are almost entirely absent with the exception of the discoidal and it has changed from the large thick type found on Kaskaskia and Big Muddy sites to a small, thin, almost straight-sided disc, many of which have been perforated in the center. There have been found here various forms of human-effigy pipes made from stone.

The problematical forms that have been found on Cypress Creek are very similar to the ones from the Big Muddy River area. The bannerstone predominates over the other forms, the plummets and cones are absent, and the discoidal is the same general type as those found on the Mississippi River village sites.

Over the whole of southern Illinois all finds of bannerstones and ceremonial objects have been made on the village sites, both large and small. Finds in mounds or burials have been confined to pottery, effigy pipes, copper and flint implements.

Dental Pathology of Prehistoric Man at the Confluence of the Ohio and Mississippi Rivers

Dr. Van Andrews
Cairo, Illinois

Material for the investigation here summarized was obtained from Mr. Fain King, who owns the Ancient Buried City in Kentucky, from the Thomas Beckwith collection in southeast Missouri, and from the writer's own collection from southern Illinois.

The burials found in southeast Missouri and in west Kentucky are very similar in that they generally occur in small conical mounds. However, the writer knows of a large village site covering approximately fifteen acres with burials scattered throughout the entire site, buried with the usual camp debris.

In southern Illinois, we have what is known as the slab-burial or stone graves. The grave is usually lined on all sides with limestone or flint slabs standing edgewise against each other. One large slab or several small ones may be used as a covering. It is not at all unusual to find the side or end of one grave forming a side or end of another. We find no special arrangement as to the direction in which they are buried. Very few artifacts are found with these burials.

We know that geographical and cultural environment play an important part upon the lives of the human race. Naturally then, the mode of living, the preparation of the food and the kind of food would, we believe, have a decided influence upon the health of the people. The particular kind of food as well as its preparation would have affected the organs of mastication then, as it does today.

The investigation was done as thoroughly and as accurately as possible. Not all specimens examined were in a good state of preservation, and due to this fact it was necessary to examine all available material. At times we had only a maxilla or a portion of a mandible containing only a few teeth. Some of the teeth examined were found loose with the burial without any osseous structure, so instead of recording the result of the examination according to an individual mouth, it is recorded regarding each individual tooth with or without the osseous structure.

This report gives the result of the investigation on individuals with fully matured mouths. Attrition is classified into four degrees;

(1) Enamel beginning to wear.
(2) Exposure of the dentine at any point.
(3) Cusps of the teeth worn away.
(4) Attrition approaching or exposing the pulp.

The teeth were also examined for caries, but the number of carious teeth only is noted, although in the examination, the location was also recorded, and the majority of cavities were found to be occlusial or mesial or distal occlusial.

	No. of teeth
Showing 1st. degree attrition	1,028
Showing 2nd. degree attrition	2,168
Showing 3rd. degree attrition	1,525
Showing 4th. degree attrition	690
Showing caries	421
Showing alveolar abscesses	71
Total examined	5,390

It is noted in the examination of the skulls that the maxilla and mandibles are large and well formed with the articulation of the teeth unusually good. We find broad well-shaped arches, seldom finding a narrow contracting one. The teeth are large, although not exceptionally so, are well formed with strong roots and thick enamel. Caries is present, especially in specimens showing third and fourth degree attrition. Occasionally one or more teeth may be found in malocclusion, which is usually linguo or bucco-version. Impactions, especially of the lower third molars are occasionally noted, also evidence of alveolar abscesses and periodontiaclasia, although the latter is rather difficult to diagnose with any degree of accuracy, due to the destruction of the osseous structures supporting the teeth. Evidence of osteomyelitis is seen occasionally.

Prehistoric man at the confluence of the Ohio and Mississippi rivers subsisted on both animal and vegetable foods, as well as on grain and nuts. Agriculture was carried on, corn being a very important food. The coarseness of the foods and the amount of grit in them, due to the preparation in stone mortors, were attributing factors to a large percentage of the teeth being found in third and fourth degree attrition. This was responsible also for a large amount of the carious teeth and for the greater percentage of alveolar abscesses. Third degree attrition was the rule in the vast majority of individuals who had reached middle age. Ante-mortem loss of teeth is noted in many instances, as well as a few edentulous cases. The result of foecal infection is manifested in some of the joints and in the vertebrae.

This single study is too incomplete to be conclusive or to be of any great value, however, it is believed that, if it were possible to make a similar survey of the skeletal material throughout the United States, and these accumulated data carefully recorded and studied, it would be beneficial and interesting to archaeologists and anthropologists.

The Dryopithecus Tooth Pattern as a Racial Characteristic of the Mound Builders

J. B. Ruyle, D. D. S.
University of Illinois, Urbana, Illinois

In order to properly understand the significance of the articulation patterns, as shown by the lower molar teeth of the aboriginal Mound Builders, it is necessary to take into account and trace the evolution of tooth structures. Passing over the long period of time which saw the gradual evolution of some primitive invertebrate form into a type which exhibited the first differentiation of the body into head and tail portions, and considering briefly the Ostracaderms of the upper Silurian period, we note that these latter gave rise to the abundant though primitive and toothless fishes of the Devonian period. First of the vertebrates to develop a masticatory apparatus were the Devonian sharks, in which the body scales surrounding the mouth were gradually drawn into the tough skin of the jaws and enlarged to form rudimentary grinding surfaces. They were arranged in rows and succeeded each other in series, as is still the case, recapitulating the relationship of the teeth to the body scales.

Fig. 1.—Left side of mandible of *Dryopithecus frickae* of the Miocene of India, showing the earliest manifestation of the "Dryopithecus pattern" on the crown surface of the molars.

The lung fishes developed a more advanced type of tooth with a recognisable base for attachment to the jaw, a double-folded structure and a thick alveolar wall. This type of tooth was carried over into the amphibians. Branching off from the amphibians, we find that the reptiles rapidly developed incisors, cuspids, premolars and molars, as well as initiating the deciduous and permanent tooth stages. Their teeth were cylindrical in cross-section.

Later the first mammals appeared, with their teeth exhibiting a triangular cross-section. At the bases of these triangular teeth on both the upper and lower jaws, there were evolved spurs on the insides. These spurs engaged each other when the teeth were in occlusion. As the anthropoid

mammals came in and progressed anatomically, their dentition was reduced. More clearly expressed—there was a progressive reduction in the number of teeth from the canines back, thus accommodating the enlargement of the brain case and the shortening of the snout and face. The lingual posterior angles of the upper molar teeth were increased, accompanied by the formation of corresponding crushing basins on the lower molars. In the teeth of the giant anthropoid apes that roamed the hills of the Mediterranean and south Asian regions in mid-Miocene time (some 14 million years ago), we find the same pattern on the lower molars that we see on those of the chimpanzee, gorilla, and man.

These teeth possess three cusps on the outside and two on the inside, against the tongue, resulting in a pattern having the appearance of a five-pointed star. All three lower molars of the giant apes show this Dryopithecus pattern, which though inherited by the teeth of modern man, varies in amount of expression with different races and individuals.

In an examination of the lower jaws of 75 Illinois Mound Builders, this pattern was found on every first molar tooth. It characterized the second molars of fifteen individuals; but was not present on any of the third molars studied. It is probable that the percentage of occurrences as applied to the second molars was in reality somewhat higher, since teeth were missing in some cases, and in others showed so much wear, due to the chewing of gritty foods, that the surface was worn flat and any original pattern obliterated. Even so, when we consider that the human race has shown a tendency towards abandonment of the Dryopithecus type molar, and having before us evidence that the teeth of the Mound Builders show a much closer relationship to the parent stock of mankind, than do those of modern races, we can safely assume that as a race they date far back into antiquity and truly represent a distinct branch of the human family tree. Contemperaneous as they probably were with the white race, they were undoubtedly more primitive in type, probably mentally, and certainly from a skeletal standpoint—their teeth supplying the evidence for such an hypothesis.

Archaeology in Southern Illinois

Bruce W. Merwin

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In previous meetings of the Illinois Academy of Science, the writer has discussed various prehistoric remains in southern Illinois and pointed out possibilities for archaeological research. The present paper makes a suggestion for a possible means of coordinating the various men and agencies interested in the field of archaeology so that the entire field can be more thoroughly covered and made available for scientific study.

There is a large number of persons in southern Illinois actively engaged in making collections of Indian artifacts. Many of these men have in turn a considerable following of farmers, schoolboys, hard-road workers, etc., who keep them informed on specimens that may have been found and on sites that have been visited or discovered. Of course the collector has to pay small amounts for this service, but it seems worth while. Some of these men are thus enabled to have such a wide acquaintance that they are kept in very close touch with archaeological discoveries.

The question comes up as to whether it would not be desirable for some organization such as the State Historical Society, the Forestry Service, State Parks, or the Department of Archaeology at the University of Chicago, to organize a clearing house in which permanent records of the findings of these men in the field could be assembled.

There are, to be sure, many objections to overcome in a plan of this sort. In the first place the collectors themselves will object. Many of them feel that the professional scientists have not been especially scientific in their work nor friendly in their attitude, and so hesitate to divulge the location of promising sites. For instance it is claimed the scientist does not remain in touch with areas studied after he has completed his field-work and hence sometimes fails to note some of the most interesting and valuable finds.

On the other hand the scientific organizations have a contempt for the research ability of the layman and feel that they should not work with the "Pot-Hunters". Still, since the local collectors will continue to excavate, explore, and collect, even if the work is done merely to secure specimens, an interview will frequently give much information regarding the occurence of various artifacts. Again, many of the local collectors have had good training. For instance one man worked for some time with Dr. Moorhead, while others have collected in the local area and have really become specialists in the local field. In fact some of these men have been able to draw interesting, tentative conclusions and, from their reading and actual finds, produce considerable supporting evidence.

Another objection is the cost of clerk hire, postage, traveling expenses, etc., but here also the cost would be less than that of maintaining a few students in the field. Federal funds might even be secured to carry on this work as a part of the Forestry Preserve movement, or in connection with some other form of public work.

All of these obstacles would serve to hinder the successful carrying through of this scheme for cooperative research; and yet it would seem that

the State Historical Society or other central agency could recognize in some way the work of these private collectors through a journal such as that of the Academy of Science if not through money. A small sum expended for travel, photographs, and carefully written records would result in a vast amount of information, from which the research men could generalize and draw conclusions supplementing and verifying the interpretation of actual scientific exploration.

The larger and more interesting sites might be secured by the state for public parks and excavated like the sites at Wyckliff, Kentucky, and Lewistown, Illinois. These new parks would possess a far greater drawing power than that of the Forest Preserves and State Parks whose main attraction is their unusual scenery.

While there may be other means for securing the cooperation and support of the local collectors, the writer feels keenly the need for some integrating agency that will in a mutually helpful and friendly manner unify the work of the scientific specialist, and the local collector. After that is accomplished the joint results should be made available to the general public.

PAPERS IN BOTANY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Botany Section consisted of twenty-two papers, eighteen of which are here represented. Not presented for publication were:

"The Problem of the Frost Flower," by Willard N. Clute, Butler University, Indianapolis, Indiana.

"The Genus *Senecio* in Illinois," by J. M. Greenman, Missouri Botanical Gardens, St. Louis, Missouri.

Harry W. Givens, Joliet, Illinois, was elected chairman of the section for 1935-36.

(Signed) W. M. BAILEY, *Chairman*

Mosses From Apple River Canyon, Mississippi Palisades and White Pines Forest State Parks

G. H. Boewe, Stella Holmes Barrick, and Stella M. Hague
University of Illinois, Urbana, Illinois

The mosses reported in this paper were collected in the fall of 1934 by G. H. Boewe and Stella Holmes Barrick.

In conformity with previous reports of Illinois mosses the names and arrangement are those given in "Mosses with a Handlens and Microscope," by Dr. A. J. Grout, and "Moss Flora of North America," Vol. 2, Part 1, and Vol. 3, Parts 1, 2, 3, and 4.

The following abbreviations are used to designate the parks where the specimens were collected: A.—Apple River Canyon; M.—Mississippi Palisades; P.—White Pines Forest

POLYTRICHACEAE

Catharinea undulata (L.) W. & M.	A. M. P.
Polytrichum Pilifera Schreb.	P.

FISSIDENTACEAE

Fissidens incurvus var. minutulus Austin	M. P.
adiantoides (L.) Hedw.	A.
cristata Wils.	M.

DICRANACEAE

Ditrichum pallidum (Schreb.) Hampe	A. P.
Ceratodon purpureus (L.) Brid.	M.
Dicranella heteromalla (L.) Schimp.	A. P.
rufescens (Dicks.) Schimp.	A. M. P.
varia (Hedw.) Schimp.	M. P.

GRIMMIACEAE

Grimmia apocarpa (L.) Hedw.	A. M.

TORTULACEAE

Weisia viridula (L.) Hedw.	A.
Barbula unguiculata (Huds.) Hedw.	A. M.
fallax Hedw.	A. M.
Tortella caespitosa (Schwaegr.) Limpr.	M.
Tortula sp.	A.

ORTHOTRICHACEAE

Orthotrichum Schimperi Hamm.	A.

FUNARIACEAE

Physcomitrium turbinatum (Mx.) Brid.	M.
Funaria hygrometrica (L.) Sibth.	A. M. P.

TIMMIACEAE

Timmia megapolitana Hedw.	A.

BARTRAMIACEAE

Bartramia pomiformis (L.) Hedw.	A.

BRYACEAE

Rhodobryum roseum (Weis.) Limpr.	P.
Mnium cuspidatum (L.) Leyss.	A. M. P.
rostratum, Schrad.	P.
Drummondii B. & S.	M.
spinulosum B. & S.	A.
punctatum L.	A. M.
stellare Reich.	M.

LESKEACEAE

Thuidium delicatulum (L.) Mitt.	A. M. P.
recognitum (Hedw.) Lindb.	A. P.
Virginianum (Brid.) Lindb.	A.
pygmaeum B. & S.	M.
Leskea polycarpa Ehrh.	A. M. P.
denticulata Sull.	M.
Austinii Sull.	A. M.
Anomodon minor (P. Beauv.) Fuern.	A. M. P.
apiculatus B. & S.	P.
attenuatus (Schreb.) Hueben.	A. M.
rostratus (Hedw.) Schimp.	A. M. P.
Thelia hirtella (Hedw.) Sull.	M.
asprella (Schimp.) Sull.	A.

HYPNACEAE

Brachythecium salebrosum (Hoffm.) B. & S.	A. M.
oxycladon (Brid.) J. & S.	M. P.
acutum (Mitt.) Sull.	M.
Eurhynchium hians (Hedw.) J. & S.	A. P.
strigosum (Hoffm.) B. & S.	M. P.
serrulatum (Hedw.) Kindb.	A. M.
Climacium Americanum Brid.	A.
Drepanocladus aduncus (var?) (Hedw.) Warnst.	A.
Campylium hispidulum (Brid.) Mitt.	M.
Amblystegium serpens (L.) B. & S.	A. M.
Juratzkanum Schimp.	A.
varium (Hedw.) Lindb.	A. M. P.
irriguum (Wils.) B. & S.	A.
(Hygroamblystegium irriguum (Wils.) Loeske)	
Plagiothecium micans (Sw.) Paris.	A.
denticulatum (L.) B. & S.	A. M.
Amblystegiella subtilis (Hedw.) Loeske	A. M.
Entodon seductrix (Hedw.) C. M.	P.
cladorrhizans (Hedw.) C. M.	A. M.
Platygyrium repens (Brid.) B. & S.	A. M. P.
Pylaisia Schimperi R. & C.	P.

LEUCODONTACEAE

Leucodon sciuroides (L.) Schwaegr.	P.

The Germination of the Seed and Development of the Seedling of *Calopogon pulchellus* (SW.) R. BR.

Margery C. Carlson

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Since Knudson's *(1, 2)* success in germinating seeds of Cattleya spp. on a sterilized nutrient medium, and in growing plants to maturity without the presence of a mycorrhizal fungus, the writer has been interested in trying to grow native members of the Orchidaceae in like manner.

Seeds of a number of species of several genera were planted on Knudson's nutrient medium. Only those of *Calopogon pulchellus* (grass pink) grew. Further germination and viability tests will be made when next summer's seeds are available, but in the meantime the development of Calopogon plants has been studied.

The seed consists of an ellipsoidal embryo, composed of a mass of parenchymatous cells, and is enclosed in a loose-fitting membranous seed coat made up of a single layer of elongated, thick-walled cells (Fig. 1).

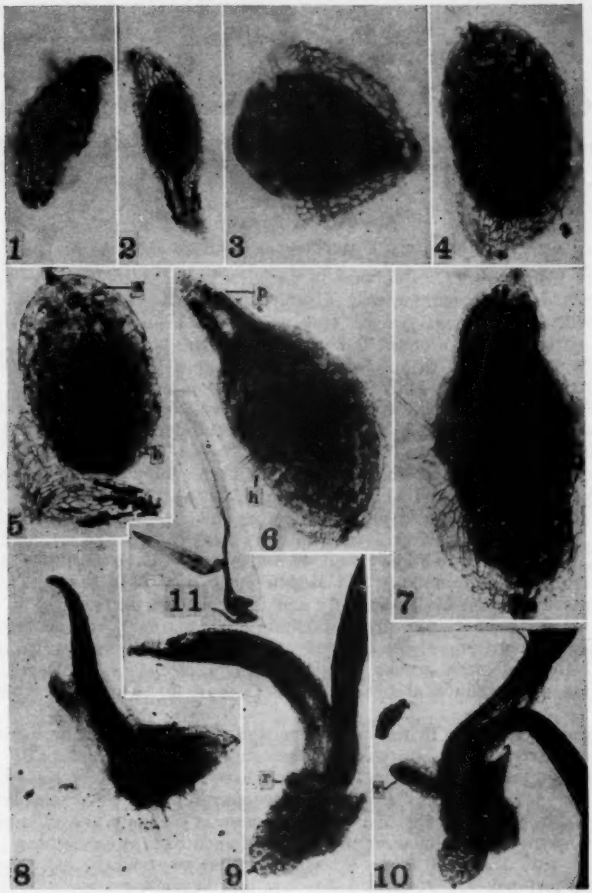
The embryo enlarges, still retaining its oval form (Fig. 2), and soon ruptures the seed coat (Figs. 3 and 4). The cells in the posterior half of the embryo continue to enlarge and become vacuolated (Fig. 5, a). The cells in the anterior region divide actively and form a stem-meristem (Fig. 5, b). A ridge, a leaf primordium, arises forming a ring around the meristematic tip. This primordium elongates and becomes the first leaf (Fig. 6, p). Certain cells, and often groups of adjacent cells, of the surface layer begin to elongate and produce absorbing hairs (Fig. 6, h) which resemble root hairs.

Chloroplasts appear in the outer layers of cells and the embryo becomes green very early. Later, starch grains accumulate in the basal half.

A greater increase in diameter occurs in the upper half of the seedling than in the lower part (Fig. 7). A second circular leaf primordium is formed within the first (Fig. 7). These primordia elongate and differentiate into leaves which are tubular at the base but open out into sheathing blades toward the tip. Figure 8 shows a seedling, about two months old, in which the second leaf has grown beyond the first and has not yet opened out into its flattened tip. The third leaf is seen just pushing up into the sheath of the second. The seed coat, the original basal part of the embryo, the enlarged upper part ("tuber") of the seedling, and the elongated absorbing hairs are also visible in this figure.

A root now forms (Fig. 9, r) in the outer part of the stem just above the attachment of the first leaf. The root digests its way through the base of the leaf and emerges. The elongating root is seen in figures 10, r and 11. The third leaf (curved downward) has emerged from the sheath of the second in figure 10, and in figure 11 the third and the fourth, or final, leaf of the first season's growth are visible.

Finally, the internodes of the stem elongate and enlarge in diameter, forming a new "tuber" which is larger than the former one (Fig. 11). A bud, or stem tip, differentiates at some point on the surface. Then the leaves die down and their bases become scale-like coverings of the new "tuber." After a period of dormancy this "tuber" develops much as did the smaller embryo of the year before.



Photomicrographs of seeds and young plants of *Calopogon pulchellus* (Sw.) R. Br. taken with Leica camera.

1. Seed, with oval embryo and membranous seed coat.
2. Germination seed.
3. Enlarging embryo has burst seed coat.
4, 5. Seedlings differentiating into posterior (a) and anterior (b) ends; emerging from seed coat.
6. First tubular leaf (p) and absorbing hairs (h) developing.
7. Second leaf forming inside first; upper half of seedling enlarging.
8. Plant about two months old, showing two leaves and beginning of third.
9. Older plant, root (r) just emerging.
10. Still older plant with three leaves and elongating root (r); new "tuber" forming; a seed at left shows relative sizes.
11. Plant about 6 months old; third and fourth leaves mature; root elongated; new "tuber" with bud at right, surrounded by tubular bases of leaves.

1. KNUDSON, L., Physiological study of the symbiotic germination of orchid seeds. Bot. Gaz. 79:345-379. 1925.
2. ———— Flower production by orchid grown non-symbiotically. Bot. Gaz. 89:192-199. 1930.

A Simple Apparatus for the Steam Method of Softening Woods for Microscopic Sections

Glenn E. Davis and E. L. Stover
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The original apparatus for softening wood by steam was introduced by Joseph Kisser, Vienna, Austria. The idea was brought to Mr. Stover by D. A. Anderson, who was studying in Vienna with Kisser. Mr. Stover developed the apparatus here described.

This apparatus has been in use in our laboratory for the past eight or nine years. It is simple to assemble and easy to operate. Live steam is simply played upon the wood while it is being cut. Water is heated in a hypsometer or steam boiler, having a capacity of about one quart. These boilers have a water gauge, an outlet for steam, and an opening for refilling. To the outlet for steam is attached a rubber tube in the end of which is inserted a glass tube drawn out in the shape of a pipette. The tube is fitted in an adjustable clamp so that it can be held out of the way.

The heating element we have used and recommend is an electric hot plate of durable construction with solid metal top, which gives an even temperature for a constant steam jet.

By using this method and a sliding microtome we have successfully cut all of the native wood, both green and old, with the exception of old wood of *Toxylon pomiferum*, which proved to be too hard to soften with steam.

It is especially noteworthy that we have been able to cut woody stems one and three years old. The steam is much easier to use than hydrofluoric acid or boiling the wood in water, which did not eliminate torn cambium cells and sections that split and cracked while being stained and mounted.

The time required to soften young stems may vary, but usually the best results were obtained by steaming for about five minutes before cutting.[1] Sections 10 to 15 microns thick showed no tearing of the cambium or pith cells. The sections did not crack and split when mounted in balsam as is common when other methods are used.

Staining is a matter of personal choice with most microtechnicians, however I wish to make mention of the fact that we have stained these sections quite satisfactorily with Delafield's Haematoxylon and safranin. Safranin is applied first and destained until only the bast and woody fibres remain a brilliant red. Delafield's Haematoxylon is applied by the dip method using ammoniated water as an intensifier and a fixer. Mature wood sections were best stained by the "quick method" of using iron alum-haematoxylon.

[1] With this apparatus it is not necessary to remove the steam while cutting.

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Effects of Sulphur Deficiency on the Growth and Metabolism of the Soy Bean

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Soy bean plants were grown in washed quartz sand in the greenhouse in the springs of 1933 and 1934. Half of the plants were given a complete nutrient solution and half a solution in which magnesium chloride was substituted for magnesium sulphate. In order to keep the plants from blooming before marked symptoms of sulphur deficiency developed, the natural day length was increased to about 16 hours by the use of electric lights.

The main symptoms of sulphur deficiency in the soy bean were: the yellow-green color of the leaves, the smaller leaves, and the thinner stems. The tops were stunted more than the roots. The upper leaves became yellow first. These symptoms are similar to those of the deficiency of other elements, for example, nitrogen, phosphorus, and calcium. This is perhaps to be expected, especially as regards the effect on color, since the deficiency of sulphur and the above elements except nitrogen causes a low reducase content of the plants, and so nitrates cannot be used, although they are present in the nutrient solution. Under these conditions the plant is naturally chlorotic, since nitrogen is necessary for the synthesis of chlorophyll. Also, sulphur may have an effect on the color of the plant due to the fact that it is a constituent of the proteins of the chloroplast, though it is not found in chlorophyll itself. It needs to be kept in mind too that calcium interferes with the absorption of nitrates. The stems of the minus-sulphur plants elongated remarkably and were almost as tall as the stems of the plus-sulphur plants. The main effects of sulphur deficiency on the chemical composition of the plant were that carbohydrates, nitrates, and soluble organic nitrogen accumulated in the minus-sulphur plants. However, this was not true of all forms of carbohydrates. Starch was higher in the sulphur-deficient plants, but the plus-sulphur plants had a higher content of sugar. Carbohydrates and nitrates no doubt accumulated in the minus-sulphur plants, because the synthesis of amino acids and other organic nitrogenous material was restricted by the low reducase content of the plants. The higher percentage of the soluble organic nitrogenous material in the sulphur-deficient plants was probably due mainly to proteolysis, the hydrolysis of the proteins. As a rule, in a plant which is poorly vegetative because of the deficiency of an essential element, the proteins are not broken down unless the plant is put in continuous darkness. The minus-sulphur plants were able to carry on this process in the light, and it was their ability to do this that accounts for the stem elongation of these plants, which was mentioned above.

Summarizing, the main symptoms of sulphur deficiency in the soy bean are: the yellow-green color of the leaves, the smaller leaflets, and the thinner stems. The tops are stunted more than the roots. The upper leaves become yellow first. These symptoms are probably due both to the lack of sulphur and to poor nitrate assimilation, which results from the low reducase content of the minus-sulphur plants. Because of poor nitrate assimilation, starch and nitrates pile up in the sulphur-deficient plants and the accumulation of starch is correlated with harder stems. The minus-sulphur plants are high in the soluble forms of organic nitrogen. This is due mainly to proteolysis and is important in the stem elongation of these plants.

A Preliminary Report of a Study of the Plants of Winnebago County, Illinois

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Since 1859 plants have been collected in the vicinity of Rockford in Winnebago County. In that period of 76 years there have been quite a few individuals who have made a study of the local plants. One of the earliest of these, and in many ways the most interesting, was Michael S. Bebb (1833-1895). There were so many sheets with his name on them in the Herbarium of Rockford College that the author's curiosity was aroused. As a result of questionings in various quarters, information regarding this unique individual appeared from the most unexpected places. So much material has come to light that a more extensive report on him will be given at a later date. An excellent biographical account of Mr. Bebb was written by Mr. Walter Deane of Cambridge, Massachusetts, and in 1896 was published in Volume 21 of the Botanical Gazette. In the bibliography given at the end of this article, the following items should be recorded here:

(1) "List of plants occurring in the northern counties of the State of Illinois, in addition to the catalogue given by Dr. I. A. Lapham." Trans. Ill. Agric. Soc. *3:* 586-587, 1859.

(2) "Recently introduced plants in and about Rockford, Ill." Bot. Gaz. *1:* 68-70, 1882.

In addition to being a well known authority on willows, Mr. Bebb made a careful study of several other groups of plants. Most of his large herbarium, originally of 50,000 sheets, is now in the Herbarium at the Field Museum in Chicago. His plants may also be found in other herbaria in the United States, since he was well known by many of the botanists who were his contemporaries, and exchanged plants with them.

So important are his collections that no list of plants of Rockford and vicinity can be considered complete until the material from his herbarium has been examined carefully and compared with that of the more recent collections. For example, on some of his sheets, he has left the notation that the plant may have been uncommon, or may have been found only recently; while the later collectors may record it as very common. Unfortunately, some of the common and beautiful plants of his day may be at present rare, or even extinct! That other changes may have occurred since those early pioneer days makes this study very engrossing.

The work initiated by Bebb has been carried on at different periods by many others—a few of these are as follows: Miss Mary Norton, Miss Frances T. Sheldon, Miss Agnes Brown, Dr. Ruth Marshall, Miss Lena Henderson, Miss Zaida Fisher (Mrs. Victor Buys), Miss Mabel Thomas (Mrs. Mathew Whelan), and Miss Mildred Willoughby. The plants collected are in the herbarium of Rockford College. The Nature Study Society of Rockford has been actively interested in local plants and has already published these two booklets: *The Trees of Rockford and Vicinity* (July, 1914) and *The Shrubs and Woody Vines of Rockford and Vicinity* (July, 1916). At present this organization, in cooperation with the author of this note, is working on the list of the herbaceous plants of this region, and expects to have it ready for publication in the near future.

Some Thoughts on Popularizing Botany

Louis F. Gumbart
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We have been in an era of "Nature Study" for some thirty years, but there are few high school students asking for botany. Fifty years ago the influence of Asa Gray on American thought was still potent and many high school students constructed and cherished "Herbariums." Why the change? We have studied biology and with a miscroscope and we have failed to create a desire to know more of plant structure as we can see it every day with our own eyes. Not in the least belittling the study of biology, why not work out a small well illustrated book of supplementary reading for seventh and eighth grades that will help stimulate a desire for plant study with a manual, by high-school time?

Such a book could start with outlines of leaves, green perhaps, showing the leaves of some of our commonest trees and shrubs, with special attention to the sharp points on black oak and round lobes on white oak types, and the freak forms of sassafras and mulberry. Second, with root forms, bulb, corm, rizome, turnip, potato and trees, with peanuts as the freak.

Third, with seeds, corn and wheat as endogen examples; then beans, peanuts, other nuts and apple and orange seeds for exogens, not illustrated, but with the suggestion that the reader put some dirt in a small box, plant the seeds, marking the places, water well and set in sunny window and keep moist—then watch them grow, noting particularly the way the two types of seed come up. Calling attention to the fact that this difference makes the fundamental division in plant life.

We are now ready for some family studies, and, to be attractive and thought and question provoking, each should have its characteristic illustration. Some of the flowers should be shown with parts separated and with the office of bees, butterflies and moths mentioned.

The Lily family with flowers in threes, onion and lily side by side.

The Rose family, flowers in fives, single and double, to show man's possibilities—there may be another Burbank among the readers. By all means stress the value of this family in food economy as well as beauty, berries, apples, peaches, pears, etc. The Mustard family, with flowers in fours like a cross, radishes, turnips, cabbage as well as some well-known flowers. The Pulse family, with flowers like a butterfly, includes beans, peas, peanuts, the clovers, etc. The Convolvulus family, flower a twisted bud opening into a trumpet, morning glory, sweet potato, dodder and bindweed.

Solanum, the true potato family, flower a five pointed star, some very bad members of which are close relatives of our good friends the so-called Irish potato, the tomato and egg plant; belladonna, henbane, nightshade and jimson (Jamestown weed), not forgetting tobacco and cayenne pepper.

Then the Mint family, with its square stems, opposite leaves and tubular flowers. A great many so-called weeds are in in it, but peppermint, spearmint, catnip, horehound and sage are all well-known to most of us as quite useful. The Composite family, with dandelions, daisies and sunflowers.

For the benefit of city children a page or two illustrating ears of corn and heads of wheat, oats, rye, barley, rice and sugar cane should be quite interesting as well as instructive. Particularly so when their relationship to the common grasses is shown.

Such a book would be quite a help toward pleasant auxiliary work for both teachers and pupils, and who knows what the stimulus might be, for some backward or bright boy or girl, toward a lot of clean fun and possible improvement in fruit, flower and forest.

Size and Ornamentation of Some Modern and Fossil Lycopod Spores

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This brief summary of the external features of the spores of a few representative genera of lycopods, both fossil and recent, is only an introduction to the problem involved in the determination of spores found isolated in shale and coal.

The genera dealt with in this paper include the extinct forms *Lepidostrobus* (the cone of *Lepidodendron*) and *Sigillariostrobus* (the cone of *Sigillaria*), and the modern forms *Lycopodium*, *Isoetes*, and *Selaginella*.

The megaspores of *Isoetes* vary in size from 250 to 900 microns. The exospore is siliceous and the color gray to white, except in *I. melanospora* where the spores are black. All of the megaspores have triradiate ridges which terminate at an equatorial ridge dividing the spore into four faces—the three upper faces and a lower or basal face. The sculpturing consists of spines, small tubercles, or reticulations, and may be similar on all faces or different on the basal face. These characters are constant in a given species, and serve as the best means of their classification. The slightly elongate microspores vary in length from 20 to 40 microns. They are smoothish, or are marked by papillae or small spines, and rarely have a winged crest. The color is usually ashy, fawn, or cinnamon-brown.

Selaginella also is heterosporous. The megaspores (Figs. 4, 5) have annular wings, while *Isoetes* megaspores (Figs. 6, 7) are wingless. The spore-body varies in diameter from 240 to 460 microns, with wings 30 to 90 microns wide. *Selaginella apus* megaspores are ornamented by reticulate ridges, while those of *S. caulescens* bear a few spines. *S. apus* microspores are 21-35 microns in diameter, are slightly rough, and have a triradiate slit.

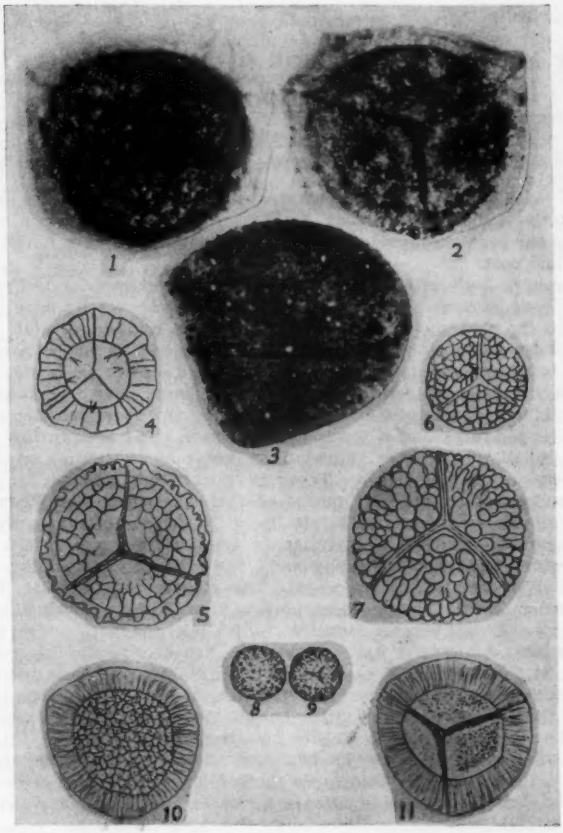
With the exception of the little known *Phylloglossum*, Lycopodium is the only homosporous lycopod. The spores compare in size with the microspores of *Isoetes* and *Selaginella*, but show distinctly the triradiate ridge and equator as in the megaspores of these two genera. The color is sulphur-yellow, and they measure 26-34 microns in diameter. The surface is usually reticulate, or occasionally ornamented with tubercles.

The megaspores of modern lycopods seldom reach a diameter of 900 microns, while those of *Sigillariostrobus* are 1,000 to 2,250 microns in diameter. The author has found in the No. 6 coal of Illinois, megaspores measuring as much as 3,100 microns in diameter, which are most likely lycopodiaceous.

The megaspore of *Sigillariostrobus ciliatus* (Figs. 8-9) compares favorably with the large megaspore shown in Fig. 3. Several similarities may be seen between the spore of Figs. 1-2 and that of *Selaginella apus* (Fig. 5). This same spore (Figs. 1-2) compares favorably with *Triletes triangulatus* type II of Zerndt (Figs. 10-11), and compares even more closely with Scott's description of the megaspore of *Selaginellites suissei*.

A close analogy may be seen between the spores of *Isoetes* and those of *Lepidostrobus*. The megaspores of *L. Veltheimianus* are 800 microns in

diameter and are covered by long stout spines. The microspores of this species and of *L. oldhamius* are often found in tetrads and are 20 microns in diameter, slightly smaller than the average *Isoetes* microspores.



Figs. 1-2, Winged megaspore x 54, with reticulate markings on basal face; 3, Megaspore x 18, covered with short spines; 4, *Selaginella caulescens* megaspore x 43; 5, *Selaginella apus* megaspore x 58; 6, *Isoetes englemanni* megaspore x 32; 7, *Isoetes malinverniana* megaspore x 36; 8-9, *Sigillariostrobus ciliatus,* echinulate megaspore x 5; 10-11, *Triletes triangulatus II* megaspore x 36.

1-2, 3, by L. C. McCabe, from No. 6 coal of Illinois; 4, after Bennie and Kidston; 6, 7, after Motelay and Vendryes; 8-9, after Scott; and 10-11, after Zerndt.

Wild Life Sanctuaries

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It was my good fortune to make a discovery last summer. Just outside the city limits of Chicago, the prehistoric Glenwood beach, a reminder of the early history of Lake Michigan, rises quite conspicuously over the prairies. Very little is left of its original tree cover in the way of oaks and maples and other plants usually found on sandy or gravelly lands in this region. Much of this growth was noted by early botanists, but one grove near the city of Niles Center apparently escaped their attention. Here last summer a colony of pepperage *(Nyssa multiflora)* was found. Some of the trees measured about eighteen inches in diameter. There must be a dozen good sized trees, quite a few smaller ones, and hundreds of saplings. The undergrowth consists of blueberries, choke berries, and other plants usually associated with these trees. On investigation to the west of the old beach quite a depression was found which years ago must have been a swamp that supplied the trees with moisture. The swamp has been drained by real estate speculators, but on its margin grew remants of several varieties of dogwood, meadow sweet, sedges, and other swamp plants. This grove, or what is left of it, represents a bit of landscape strange to this region. The pepperage and some of the other plants are pioneers that have marched westward from their original home, and as far as the writer knows, with the exception of a few scattered plants in south Evanston which are dying, and a group reported by Dr. Pepoon in Rogers Park, destroyed long ago, there is no other record of these trees anywhere else in this region. In other words, they are on the western rim of their natural habitat.

The few remaining tamerack bogs in the Fox Lake area were also explored last summer. One of them was found to contain several groups of yellow birch *(Betula lutea)* so rare in Illinois, but still more surprising was a section of this bog with mountain ash in all stages of growth. The older trees were suffering from scarcity of moisture. Perhaps too their vitality is poorer in this southern home. These two varieties, yellow birch and mountain ash, as far as the writer knows, are on the southern rim of their natural habitat. The undergrowth consists largely of grey dogwood, *Ilex verticillata*, *Vaccinium arborium*, and numerous ferns. This bog is located a few miles east of Antioch.

Of the other bogs, one especially has become familiar to botanists and teachers because of its unusual character and its northern flora. The pitcher plant *(Sarracenia purpurea)* is quite numerous, also several varieties of the orchid family and other plants rare in Illinois. There were a few scattered yellow birch saplings and one was puzzled to know where they had come from. Poison sumac *(Rhus vernix)* is also plentiful. Years ago this bog had quite a pool of water in the center; an old boat hidden in the rushes told the story of its former depth. Last season it was a mud flat with a few turtles plowing through it in search of water. This open center is surrounded by rushes, cattails, and other bog plants, followed by tamarack and plants associated with them. It is the most complete tamarack bog the writer has seen.

The problem of chief interest is what is to become of these plant sanctuaries which teach us the natural migration of plants, the struggle for the survival of the fittest, and give us an understanding and knowledge not to be found anywhere else and therefore most essential to our intellectual growth. Their destruction, and this is on the way, is due to our failure to understand that all life is part of the same creation, linked together into a wholesome growth in the evolution of things.

My suggestion is that such sanctuaries, wherever found, should be preserved and become part of our educational system rather than our political system. They should be accessible, to a degree consistent with their preservation, to all centers of learning. They might come under the supervision and belong to more than one school district in the vicinity of which they are found, so that the expense of guarding them from exploitation would not fall on one district alone. The State should also share in the purchase of these tracts and in their upkeep.

Collection of Fleshy Ascomycetes From East Central Illinois

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This collection of fleshy ascomycetes was made rather causally over the last ten years, however more species were found last fall than in any one preceding year. The collection was made by Mr. Stover, other members of Botany Department staff, and students. All species were collected in Coles, Clark, and Edgar Counties. The names are those used by Seaver in "North American Cup Fungi"[2] except Leotia and Geoglossum, forms not described by Seaver.

This collection consists of forty-one representatives; nine genera of *Pezizaceae*, two genera of *Elvelaceae*, two species of *Leotia*, and *Geoglossum glabrum*.

PEZIZACEAE

Bulgaria rufa Schw.	May
Humarina araneosa (Peck) Seaver	Sept.
Humarina spp.	Sept. Oct.
Patella albida (Schaeff.) Seaver	Oct.
Patella scutellata (L.) Morgan	Oct.
Paxina corium (Weberb.) Seaver	summer
Paxina hispida (Schaeff.) Seaver	summer
Paxina olivaceae (Clements) Seaver	Sept. Oct.
Paxina platypodia (Boud.) Seaver	Sept. Oct.
Paxina semitosta (Berk. and Curt.) Seaver	Sept. Oct.
Paxina subclavipes (Phill. and Ellis) Seaver	Sept. Oct.
Peziza badia Pers.	Sept. Oct.
Peziza brunneoatra Desm.	Sept. Oct.
Peziza griseorosea Ger.	Sept. Oct.
Peziza repanda Pers.	Sept. Oct.
Peziza succosa Berk.	Sept. Oct.
Peziza sylvestris (Boud.) Sacc. and Trott.	Sept. Oct.
Peziza violacea Pers.	Sept. Oct.
Plectania floccosa (Schw.) Seaver	spring
Plectania occidentalis (Schw.) Seaver	spring
Scodellina leporina (Batsch) S. F. Gray	Sept. Oct.
Sphaerospora brunnea (Alb. and Schw.) Massee	Sept. Oct.
Sphaerospora hinnulea (Berk and Br.) Massee	Sept. Oct.
Urnula craterium (Schw.) Fries	spring, summer, fall

ELVELACEAE

Elvela albipes Fuckel	Sept. Oct.
Elvela atra (Pers.) Boud.	Sept. Oct.
Elvela brevissima Peck	Sept. Oct.
Elvela caroliniana (Bosc.) Nees	April
Elvela crispa (Scop.) Fries	Sept. Oct.

Elvela elastica Bull. Herb. Fr.	Sept. Oct.
Elvela Klotzchiana Strum.	Sept. Oct.
Elvela underwoodii Seaver	April
Morchella angusticeps Peck.	April May
Morchella conica Pers.	April May
Morchella crassipes (Vent.) Pers.	April May
Morchella deliciosa Fries.	April May
Morchella esculenta (L.) Pers.	April May
Morchella hybrida (Sow.) Pers.	April May
Leotia lubrica Pers.	Aug. Sept.
Leotia chlorocephala Schw.	Aug. Sept.
Geoglossum glabrum Pers.	Oct.

The general opinion seems to be that fleshy ascomycetes are vernal. Most of this collection was made in the fall. The species of Morchella, large forms of Elvela *(E. carioliniana, E. underwoodii)*, and six species of Pezizaceae were the only forms collected in spring. V. O. Graham,[1] Chicago reported *Peziza badia, P. sylvestris, P. repanda* and *P. violacea* as appearing in spring in the Chicago region. These species of Peziza were collected in September and October in Eastern Illinois. *Patella scutellata* also reported as a spring form by Graham was collected here in the fall. *Urnula craterium* was found in spring, summer, and fall. It was more abundant in fall.

These specimens may be found in the herbarium at Eastern Illinois State Teachers College.

REFERENCES

(1) Graham, V. O., Ecology of Ascomycetes of the Chicago Region, Trans. Ill. State Acad. Sci. Vol. 25, 1933.
(2) Massee, George, British Fungus-Flora, Vol. 4, 1895.
(3) Seaver, F. J., The North American Cup-fungi (Operculates), 1928.

Conservation of the Wild Flowers of Illinois

Harry W. Mauntel

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Nature's garden has been ruined and in many cases destroyed by man who stands bewildered as he realizes the true situation, wondering how to repair the damage. Many meetings are planned, lectures given, and even Legislative interests are aroused, but little actual work is done about replenishing and remaking the despoiled woodlands. We in America must take a cue from our friends across the Atlantic and restore the beauties of nature in the form of natural forests (not artificial parks), wild open prairies, and in fact in every nook which can not be classed as productive agricultural land. This unproductive land could again be made to give to future generations some of its original glories.

We should start in the home, school, and community to educate the people to the beauties of nature and the healthful outdoor life. True it is today as in years gone by, many individuals lack understanding and interest in the fast disappearing native wild flowers. Nevertheless much interest has been aroused and a movement is on foot for the reforestation of many acres of waste and unproductive land, so why not incorporate in this plan a program of wild flower conservation.

Each year in Illinois, as in other states, when spring arrives the roads are crowded with the traveling public on their way to the scattered woodlands and groves to make a wholesale raid on the few remaining patches of wild flowers. The hepatica *Hepatica triloba*, trillium *Trillium grandiflorum*, lady slipper *Cyprepedium parviflorum*, bloodroot *Sanguinaria canadensis*, bluebell *Martensia virginica*, white adders tongue *Ophioglossum vulgatum*, dutchman's breeches *Bicuculla cucullaria*, as well as the common violet will soon suffer extermination if this thoughtless destruction of wild flowers continues. Most of the wild flowers are so delicate that within a few hours they are wilted and withered and as a result are consigned to the roadside or ash heap, the beauty of the woodland faded. The same is true of our native trees and shrubs such as the red bud *Cercis canadensis*, dogwood *Cornus florida*, and wild crab *Prunus serontina*, which being defaced, soon die.

If we must have these native wild flowers in our yard or garden, let us make a careful study of the habitat of each flower and then select with a scientific plan the desirable environment for each particular plant in the new surroundings. For example, we know that the heavy tuberous roots of the bloodroot *Sanguinaria canadensis* can be readily transplanted into a shady nook in the wild flower garden. This is also true of the trillium *Trillium grandiflorum* and *T. sessile* and the jack-in-the-pulpit *Arisaema triphyllum*.

Illinois has passed some legislation protecting a few of the wild flowers that are becoming rare in some localities. This act, approved June 21, 1923, protects the bloodroot *Sanguinaria canadensis*, lady slipper *Cyprepedium parviflorum* and *C. hirsutum*, columbine *Aquilegia canadensis*, trillium *Trillium grandiflorum* and *T. sessile*, lotus *Nelumbo lutea*, and *Gentiana crinita* and *G. andrewsii*. With the passage of this act, Illinois became the second state in the Union to pass a law protecting her plant resources.

Through the splendid organization, The Wild Flower Preservation Society (Illinois Chapter) much valuable work has been accomplished in

getting the people of our State acquainted with the native wild flowers, what flowers to protect, and how to protect the rare wild flowers.[1] Much interest could be aroused regarding the conservation of native flowers if there could be organized a definite program of conservation. Various societies or organizations (Woman's club, Kiwanis, American Legion) could carry on this work through posters, interesting lectures, exhibits, and community gatherings as has been done in other states. In the District of Columbia a campaign was made to save the dogwood.[2] Posters and pleas were disseminated through the following agencies: Theater owners, street cars, florists, merchants, Boy Scouts, Girl Scouts, and newspapers. The results were excellent and the dogwood, so common and natural to that section of America, was saved for future generations because the public was aroused, and therein lies our strength.

Following are certain rules regarding the picking of wild flowers which could be used on posters or in leaflets for the education of the public: In picking flowers let us remember (1) That what we have picked and carried away can no longer be enjoyed by anyone else in the place which they made beautiful; (2) that although it is tempting to pick a place clean of every wild flower, most of them will probably be withered before we reach home; (3) that, most important, there will not be enough flowers left in the place to go to seed and make it beautiful again next year.[3]

Other educational information may be used on posters; the following has been used in Illinois to educate its citizens:

HELP US SAVE THE WILD FLOWERS[4]

> The trillium, lady's slipper, gentian, bloodroot, columbine, lotus, and many of our lovliest wild flowers are fast disappearing from Illinois. Do not pick them—picking flowers destroys their seed. Leave them to beautify the earth. Be a lover, be an enjoyer, be a protector of wild flowers.

We must enlist the aid of the schools of our State in conservation, creating an interest among the teachers and students in Nature's gifts so that this movement will be carried into the future. Interesting lectures, posters, and visual education will implant in the receptive minds of students the proper respect, admiration, and knowledge pertaining to Nature and her ways. The student should be brought into actual contact with nature through field trips conducted by experienced teachers or nature lovers who demonstrate conservation by being satisfied with a few plant specimens and do not molest the rare specimens at all. They should be taught to study the plants in their natural environments rather than to pull them up or pick and take them back to the laboratory. If these suggestions were carried out in our schools and communities there would be little danger of some wild flowers becoming extinct and others so rare, and our new forest sanctuaries and few remaining prairies would again blossom forth in the glories of nature as in the past.

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[1] A list, with rules for picking of the wild flowers in Illinois, has been prepared by the Wild Flower Preservation Society of Illinois for distribution to the citizens of this State.

[2] Nature Magazine, April, 1925, p. 249.

[3] Society for the protection of Native Plants, Suggestions about Wild Flowers. Leaflet No. 29, 1918.

[4] Wild Flower Preservation Society, Illinois Chapter, Chicago, Ill.

Some Effects of Fuel Oil on Plants

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ABSTRACT

Experiments were carried on with the tomato, the peach, the apple, and with *Ageratum houstonianum*. These exhibited marked variation in their reaction to oil applied to the soil in which they were growing. Where the oil actually entered the tissues a slow death followed. In other cases rather sudden death occurred with no traces of oil within the plant tissues. The experiments lead to the conclusion that commercial fuel oil has a harmful effect when brought into contact with the roots of plants and that the effect is fatal when the quantity is raised above the critical point for the species.

This article has been published in full in Plant Physiology 10: 817-820. 1935.

Some Paleozoic Gymnosperm Seeds and Their Evolution

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Early in my collecting of fossil plants in Illinois, I was struck by the abundance of Gymnosperm seeds throughout the entire range of Pennsylvanian strata. The seeds belonged primarily to the orders of Cycadofilicales, and, in some instances, of Cordaitales. Both groups were assumed to have disappeared at the end of Permian time. In September, 1934, I had a chance to examine the type material of G. R. Wieland's Bulletin 31 of the Instituto Geologico de Mexico, in which he describes the Flora Liasica de la Mixteca Alta from the state of Oaxaca, and also of the Bulletin 34 by E. D. Lozano on the Liassic plants of Huauchinango, in the state of Veracruz. These so-called Liassic floras contain an abundance of typical Cordaites leaves and Trigonocarpus seeds. The Cordaites go mostly under the name of Noeggerathiopsis, but are typical Eu-Cordaites. The Trigonocarpus and Rhabdocarpus were allowed to keep their genuine names. I found also a number of seeds which seemed to me to be typical Cordaites seeds, but which were called Cycadospermum. I called upon Dr. Carl Burckhardt, retired Geologist of the Mexican Survey, who had published a most complete treatise on the Mesozoic of Mexico. He assured me that the floras of Mixteca Alta and Huauchinango were not Liassic but Dogger. These identifications prove that the Cycadofilicales and Cordaitales can be traced to the Middle of the Jurassic. It would be extremely interesting to follow this clue and to try to establish the connection between these Cycadofilicales and the Cycadophytes which latter form the bulk of the fossil floras of Mixteca Alta and Huauchinango.

A good impression of Codonospermum from coal No. 2 at Spring Valley near LaSalle in Illinois, was published in my Bulletin 52 of the Illinois State Geological Survey, and a beautiful Trigonocarpus seed was found protruding from a coal ball collected near Booneville, Indiana, in the coal seam No. 5 of Illinois-Indiana. It has not yet been cut, but a similar Trigonocarpus seed from another coal ball which had been cut showed practically no structure, but had a little Pecopteris leaf under its sclerotesta. A great many seeds found in coal balls have been sectioned and we are able to see, in many of them, the megaspore membrane, the pollen chamber, the tapetal layer of the nucellus, also the pollen in the pollen chamber, but no embyro has yet been found, although we sincerely hope that that may happen some day.

Types of Pitting in Conifers

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This survey is an exposition of those types of pitting which, by virtue of their predominant occurrence in certain taxonomic groups, are regarded as typical. The work is largely compiled from existing literature so organized as to be useful in the diagnosis of coniferous woods. The terms are largely those encountered in the literature, supplemented by certain tentative terms. To select and test those types worthy of recognition, approximately 140 specimens of 95 species, embracing 35 genera, have been examined and have furnished the illustrations. The inexperienced wood diagnostician is cautioned to use these type-characters only in combination with others, owing to the great variability in the anatomy of individual specimens. The classification of Pilger[1] and the anatomical terminology approved by the International Association of Wood Anatomists[2] are employed throughout.

SURVEY OF TYPES*

Tracheids

Abietinean.—This is a condition featured by opposite pitting on the radial walls of the deep[3] tracheids of early wood, passing to uniseriate arrangement in the remainder of the growth ring (Fig. 1). The pit borders of opposite pit-pairs are isodiametric and often somewhat compressed at the contiguous edges. Low magnifications suggest vertical crassulae (bars of Sanio) at these lines of juncture, which are shown to be illusions when a higher magnification is employed (Fig. 2). The pit borders of uniseriate pit-pairs present a wider face view and approximately the same height as do those of opposite pitting. Abietinean pitting occurs typically in the Pinaceae, with slight modification in most of the remaining conifers. The exceptions will be noted below as distinctly different types.

Araucarian.—The Araucariaceae are distinguished from all other conifers in two important features of tracheid pitting. These are briefly enumerated as, (1) absence of crassulae, and its corollary, (2) various arrangement of pit-pairs (Fig. 3). Pit-pairs are often crowded in such fashion as to present pentagonal or hexagonal margins of the pit borders. Often they are arranged in horizontal rows, but alternate vertically; quite as often they may be in vertical rows, horizontally alternate. Or they may have a two-dimensional symmetry or none whatever. Within the family, the preponderant number of vertical rows per tracheid may be used as a distinction.

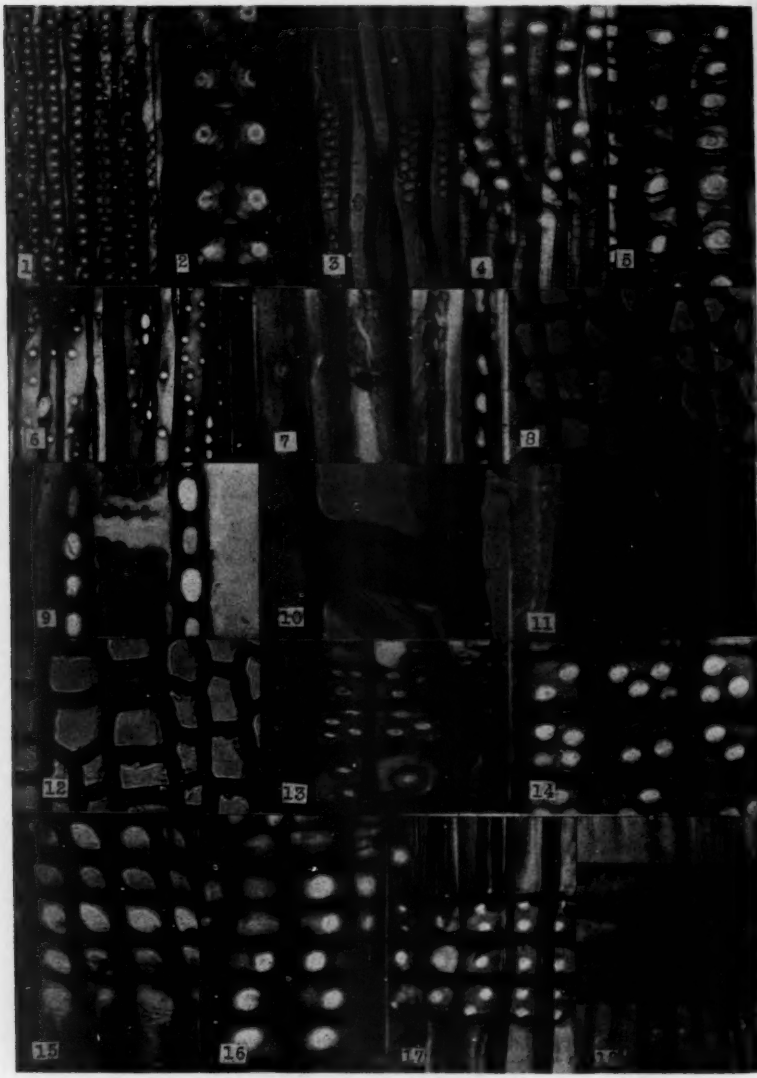
Taxinean.—This type is characterized throughout by the occurrence of slender spiral bands of secondary thickening in the tracheid walls (Fig. 4). Bordered pit-pairs are uncrowded and almost without exception uniseriate; the spirals often traverse the borders of the pit-pairs above and below the pit aperture. This type of tracheid sculpture occurs in the Taxaceae and

* Thanks are due Dr. John T. Buchholz for valuable criticism, the Yale School of Forestry for the greater portion of the materials, and the Field Museum of Chicago for the remaining specimens.

[1] Engler and Prantl. 1926. Die Natürlichen Pflanzenfamilien, Band 13.

[2] Committee on Nomenclature, International Association of Wood Anatomists. 1933. Glossary of terms used in describing woods. Tropical Woods 36:1-12.

[3] The radial dimension of tracheids is referred to as "depth", to distinguish from the tangential "width".



1. ***Pseudolarix kaempferi*** (Lind.) Gord. Radial, x100.
2. The same. Radial, x500.
3. ***Araucaria excelsa*** (Lamb.) R. Br. Radial, x125.
4. ***Taxus brevifolia*** Nutt. Radial, x250.
5. ***Callitris glauca*** R. Br. Radial, x400.
6. ***Fokienia maclurei*** Merill. Tangential, x150.
7. ***Juniperus virginiana*** L. Tangential, x450.

Cephalotaxaceae, where it may be used diagnostically on the basis of thickness and frequency of spirals. Similar spirals occur in *Pseudotsuga* and in some species of *Picea*.

Callitris.—The tracheids of most species of *Callitris* possess peculiar secondary thickenings which are superposed upon the upper and lower portions of the pit border. These thickenings are slender bands resembling the spirals of *Taxus* in structure. However, they are isolated bands and often lend the appearance of shielding the pit border, since they do not traverse the pit aperture but are convergent at the outer margins (Fig. 5). Distinctions within the genus may readily be made on the basis of this character.

Tangential.—In every observed specimen the tangential walls of late wood tracheids have been found to possess bordered pit-pairs (Fig. 6). These are usually smaller than the radial pit-pairs of earlier wood and are isodiametric. The pit aperture is quite small, elliptic, and its long diameter is inclined slightly from the vertical. In section the border exhibits the bluntness characteristic of all bordered pit-pairs formed in thickened tracheid walls of late wood.

Wood Parenchyma Transverse Walls

Juniperus.—The transverse walls of wood parenchyma cells show three distinct variations in the matter of pitting. One of these is found in some species of *Juniperus* and consists of a rather thin wall with delicate knobs of secondary thickening (Fig. 7). The transverse view shows distinctly the communicatory nature of these simple pit-pairs (Fig. 8). This character is intrageneric in the Cupressaceae.

Taxodium.—In this type the transverse walls of wood parenchyma cells are considerably thicker and possess correspondingly coarser thickenings (Fig. 9). The transverse view is somewhat similar to that of the *Juniperus* type, although the characteristic coarseness may still be noted (Fig. 10). A considerable degree of constancy renders this character of diagnostic value among the genera of the Taxodiaceae.

Cupressus.—This type is featured by absence of pitting rather than by any peculiarity in pit-pairs (Fig. 11). The transverse walls are moderately thick and devoid of the knob-like structures described above. This conclusion is borne out by observation of transverse (Fig. 12) and radial sections as well. This is also a useful character, since it may be used generically as well as within certain genera of the Cupressaceae.

Xylem Ray Crossfield[4]

Taxodinean.—This type is characteristic of the Taxodiaceae, with few exceptions. The relatively deep tracheids produce a wide crossfield, with the result that generally from two to four pits are formed abreast. In usually high ray cells, therefore, there may be eight pits in a crossfield. The pit aperture is large and elliptic, ranging from horizontal to

[4] That area of a tracheid wall delimited by the walls of a crossing ray cell.

8. The same. Transverse, x400.
9. *Taxodium distichum* (L) Rich. Tangential, x350.
10. The same. Transverse, x500.
11. *Fitzroya cupressoides* (Molina) Johnston. Tangential, x550.
12. The same. Transverse, x325.
13. *Sequoia gigantea* (Lindl.) Dec. Radial, x325.
14. *Glyptostrobus pensilis* Koch. Radial, x325.
15. *Podocarpus nagi* (Thunb.) Zoll et Moritzi, Radial, x325.
16. *Sciadopitys verticillata* Sieb. et Zucc. Radial, x350.
17. *Juniperus ashei* Buchholz. Radial, x450.
18. *Cupressus macnabiana* Murr. Radial, x300.

slightly inclined; the pit border is regularly circular (Fig. 13). The width of the border above and below the center of the aperture approximately equals the short diameter of the aperture.

Glyptostroboid.—This is a modification of the *Taxodinean* type in that the aperture is larger and the border correspondingly narrower (Fig. 14). The border occasionally appears as an extremely thin "halo," and in the earliest wood purely simple pits are found. This type is characteristic of *Glyptotsrobus* and may be found sparingly among other genera of the Taxodiaceae.

Podocarpoid.—In the podocarps the prevalent type of crossfield pitting consists of irregular pits, simple in early wood and elliptically bordered in late wood with a distinct gradient occurring through the year's growth. The predominant form is ovoid, very seldom occurring in excess of two in a crossfield (Fig. 16). They resemble greatly the simple pits of the *Glyptostroboid* type, and occur as most typical in early wood.

Sciadopityoid.—The pits occurring on the crossfields of *Sciadopitys* are the logical choice for discussion at this point. The crossfield of early wood bears one large simple egg-shaped pit-pair (Fig. 15). The gradient in this type shows a decrease in border size accompanied by a greater decrease in aperture size. The late wood pits possess a long narrow aperture approaching the vertical, and a still rather broad elliptic to circular border. The form of the early wood pits have no parallel among conifers, the closest approximation being the ray parenchyma pits found in white pines.

Cupressinean.—The last of the distinct crossfield pitting types to be discussed here is that found in general among the Cupressaceae. This is perhaps a less definite type than those preceding. Those pits considered as typical are small, occurring from one to two (occasionally four) in a crossfield (Fig. 17). The pit borders are usually circular throughout the year's growth and the apertures are characteristically slit-like, ranging from oblique to vertical, even in the early wood.

Xylem Ray Tangential Walls

Juniperoid.—The pitting on tangential walls of ray cells falls into two general types. The first of these is termed "*Juniperoid*" and is of frequent occurrence in the Cupressaceae, where it may be employed generically as well as within certain genera. The walls exhibiting this type of structure range from very delicate to moderately thick, and are equipped with knob-like thickenings similar to those described for the transverse walls of wood parenchyma (Fig. 17). No attempt is made here to separate this feature into two types according to coarseness.

Cupressoid.—The second general type of tangential ray cell wall is smooth and entire (Fig. 18). The walls showing this condition may vary considerably in thickness in different species, while remaining moderately constant within species, illustrating the diagnostic possibilities of this character.

SUMMARY

Illustrated descriptions are given of various moderately constant "types" of conifer pitting. Among these are four conditions occurring on radial walls of tracheids, three occurring on transverse walls of wood parenchyma, five on crossfields, and two on the tangential walls of ray cells. The descriptions are accompanied by the general distribution and potential diagnostic value of the types. Care should be taken to use these characters only in combination with others, because of great variations in wood anatomy.

The Origin of Adventitious Roots From Leaf Cuttings of *Saintpaulia ionantha* Wendl.

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ABSTRACT

Leaf cuttings of Saintpaulia, which is commonly known as the African violet, were found to root readily from the cut surface of their petioles within 18 to 20 days after planting in moist sand boxes. The purpose of this investigation was to study the origin and development of adventitious roots thus formed.

Microscopic sections of the basal portions of petioles, which had been planted from 4 to 18 days, were studied and compared with vertical and transverse sections through petioles of various ages, which had not been planted.

The first noticeable change from the normal structure of the petiole is the formation of a zone of meristematic activity in a region immediately surrounding the vascular bundles (Fig. 2, a). This activity appears to be correlated with a basal enlargement of the petiole.

A circular trough is formed by the disintegration of parenchyma cells in a region immediately outside the zone of increased activity. This disintegration of cells and the failure to produce callus tissue are attributed to the succulent nature of the petiole.

Root primordia are initiated within the zone of increased activity by the division of small groups of parenchyma cells in: (a) the undifferentiated central region in one side of the vascular bundle; (b) a region in line with the undifferentiated central region of neighboring bundles; (c) the parenchymatous zone adjacent to the xylem or phloem of a vascular bundle.

The formation of a root primordium involves the change of several parenchyma cells from an inactive to a meristematic condition, and subsequent radial and tangential divisions of these cells.

Growth of the primordium is by: (a) the division of initial cells, (b) enlargement of newly formed cells, (c) initiation of divisions in adjacent parenchyma cells and their incorporation into the root complex.

Differentiation of root tissues begins soon after the organization of the root apex.

A young root grows at right angles to the axis of the petiole, but turns down before reaching the epidermis. Roots begin to emerge through the cut surface of the petiole 18 days after planting, and within 8 to 10 days after their initiation (Fig. 1).

Fig. 1a. Petiole 3 weeks after planting. 1b. Petiole with adventitious shoot. 2. Cross-section of mature petiole. 2a. Crescent of vascular bundles surrounded by parenchyma cells in which divisions in localized groups of cells are initiated. 3. *Saintpaulia ionantha* Wendl.

The Paleobotanical Significance of Plant Structure in Coal*°

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Some remarkable plant structures may be obtained from bituminous coal by the various techniques now available. The methods generally practiced are: (1) Thin section technique, whereby the sections are ground until they become translucent; (2) relief polishing and etching procedure; and (3) maceration, in which all the humified material is removed, leaving the chemically resistant parts free of the matrix.

In thin sections of coal, cuticles and spores are clearly shown in cross section and have been abundantly figured in the literature of coal microscopy.[1] Recent results of etching procedure are discussed by W. S. McCabe in this same volume.[2] Maceration technique as applied to Illinois coals has been reported by L. C. McCabe[3] who presented the first general proof of the applicability of the maceration procedure to Illinois coals. Other techniques are given by Zerndt[4] and Jurasky.[5]

The material presented here has been obtained through study of thin sections and macerated residues of Illinois coals No. 5 and 6 at the Illinois Geological Survey. Spores and cuticles, because they are resistant to chemical oxidation, are well adapted to study by maceration.

Some of the microsporangial spore groups from coal No. 5, Williamson County, are shown in Plate I, Figs. 1-4. The narrow elliptical grouping indicates fructifications of synangial nature, roughly comparable with those figured and described by Halle[6] in a recent paper. Since the spores were embedded while still in their sporangia and are relatively small, they probably represent immature organs that had not attained full growth. Additional studies of this coal using maceration and etching methods will reveal more about these organs.

The salient external characteristics of the genus *Triletes* Reinsch[7] are illustrated in the diagrammatic drawings (Pl. I, Figs. A, B, and C). This is the name applied to some of the large trisymmetric lycopod megaspores so

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° Acknowledgement is given for materials, facilities, and cooperation rendered the author while employed as research assistant to Dr. G. H. Cady under a cooperative agreement with the National Research Council, at the Illinois State Geological Survey.

[1] Thiessen, R., U. S. Bureau of Mines Bul. 117, 1920; et seq.; also others cited here.

[2] Page 177.

[3] McCabe, L. C., Some Plant Structures of Coal: Trans. Illinois State Acad. Sci. 24:321-6, 1931.

[4] Zerndt, Jan, Les Megaspores du Bassin Houiller Polonais. Academie Polonaise Des Sci. et Lettres, Comite Des Publications Silesiennes—Travaux Geologiques No. 1, l'ere partie, Krakow, 1934, p. 3.

[5] Jurasky, K. A., Die Macerationsmethoden in Palaobotanik. Handb. biol. Arbeitsmethoden, Abt. XI, teil 4, 331, 1931.

[6] Halle, T. G., The Structure of Certain Fossil Spore-Bearing Fructifications Believed to Belong to Pteridosperms. Kungl. Svensk. Vetensk. Handlingar, Tredje series, B. 12, No. 6:1-103, 1933.

[7] Reinsch, P. F., Micro-PalaeoPhytologia Formationis Carboniferae. Theo. Krische, Erlangen: Bernard Quaritch, London: 1884 (Reviewed by Bartlett, H. H., The Genus Triletes, Reinsch. Mich. Acad. Sci. Arts and Letters, 9:29-30:1928).

common in coal and in some carboniferous shales. The descriptive terminology has been in part rendered from the German and French and in part from current botanical usage. A few additional designations are here introduced where an appropriate term seemed to be lacking. It is hoped by the presentation of this fairly complete terminology to encourage the use of more adequate descriptions in new species subsequently described.

Triletes Reinsch

Triletes cf. giganteus Zerndt

(Pl. I, Fig. 5)

This is an enormous megaspore of the division Laevigati which has been described by Zerndt.[8] It reaches a maximum length of over 6 mm. Although not common in any Illinois coal thus far examined, it is present in No. 6 coal at several localities. This specimen consists of only the proximal portion, to which abortive sister spores are attached, a fairly characteristic condition. This is the first record of occurrence in this country. European localities are given by Zerndt[9] and by Wicher [10] in the Polish coal basin and the Ruhr respectively.

Triletes triangulatus Zerndt

(Pl. I., Fig. 6, *a* distal surface, *b* proximal surface)

This type of spore is assigned to the division *Zonales*, due to the well developed equatorial flange. In size and form this spore is not dissimilar to those of some present day species of Isoetes or Selaginella. The distal surface of the body of this spore (Fig. 6 *a*) shows a definite coarse reticulation. The surfaces of the pyramic areas ordinarily have a dull-textured even surface. Maximum diameter of the individual shown, measuring diagonally from one radial extremity, is 732 mu. The body of the spore is 532 mu in diameter.

The species is apparently also found in the Polish and in the German Carboniferous coals, although later work may differentiate within the group that is given here as a single species.

Monoletes Ibrahim 1933

Monoletes was proposed by Ibrahim[11] as a provisional name for spores having one "dehiscence" mark and bilateral symmetry, a designation coordinate with the Reinsch genus *Triletes*. It is used here in this sense and is regarded as a useful addition to spore nomenclature. As more information accumulates, it may be desirable to restrict the genus to spores of the general character seen in those mentioned below, although it would be premature to do so now.

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[8] Zerndt, Jan, Triletes giganteus, n.sp., eine riesige Megaspore aus dem Karbon. Bull. International De l' Academie Polonais d. Sci. et Lettres, Ser. B. vol. 1(7) ;71-79; 1930.

[9] Zerndt, ibid. 1930; also 1934.

[10] Wicher, C. A. Sporenformen der Flammkohle des Ruhrgebietes. Arbeiten aus dem Institut für Palaobotanik und Petrog. der Brennsteine Band 4, (IV), p. 172, 1934.

[11] Ibrahim, A. C. Sporenformen des Aegirhorizonts des Ruhr Rievers. Dissertation, Berlin, (1932), published 1933.

A form considered as new, which occurs in great abundance in Illinois No. 6 coal agrees with this generic diagnosis and shows general similarity with one of the species included in *Monoletes* by Ibrahim.[12] [13] Unfortunately Ibrahim relied almost entirely on descriptive formulae in the works cited. These do not permit the flexibility so necessary for precise description nor is his accompanying figure sufficiently detailed to establish the precise characteristics of the spore resembling the new species of *Monoletes* here described. As far as may be ascertained, however, the Illinois form is quite distinct from Ibrahim's species which we will refer to as *Monoletes ellipsoides*.

In the previously mentioned paper by Halle, the spores of Whittleseya and Goldenbergia are illustrated and both agree fairly well with the new *Monoletes*. In general the latter is larger than those of Halle but the resemblance is so close that the plants may have been identical. Spores of *Codonotheca caduca* described and figured by Sellards[14] are also smaller and may be readily distinguished by other features; however, if found separated from the fruiting structures, the spores of *Codonotheca* would also be assigned to *Monoletes*. The *Dolerophyllum* prepollen described by Renault[15] likewise is similar in general appearance. It would seem more in keeping with the known facts to class isolated spores of this type also with *Monoletes* rather than assigning them, perhaps erroneously, with *Dolerophyllum* as Zerndt[16] does.

Monoletes ovatus sp. nov.* is the name proposed for this spore, as shown in Pl. I, Fig. 7, found in its characteristic occurrence, separate from identifiable remains of the mother plant. Holotype, designated "Monoletes ovatus", slide collection of the Illinois State Geological Survey, Belleville column (No. 3), Bench 3, Section 30, from Illinois coal No. 6 at Belleville, Illinois.

The dimensions of the spore body average about 450 mu in length and 340 mu in breadth. The haptotypic[17] structures (i. e. "due to contact and other relations with their neighbors during growth"), show that this spore was probably the result of succedanic mother cell division.[18] The faces of juxtaposition in tetrad (corresponding to the pyramic areas of trisymmetric spores) are of varying width, usually about one-half the short radius of the spore or about 85 mu near the center. The marginal lines of these two faces

[12] Described as: *Sporonites ellipsoides*, Potonie, Ibrahim & Loose Sporenformen aus den Flozen Agir und Bismark des Ruhrgebeites. Neues Jahrbuch fur Min. Geol. u. Paleont., Beilage Bd. 67, Abt. B. 449, 1932. Also as: *Laevigato-sporites ellipsoides*, Ibrahim, Ibid, p. 40, 1933. There would seem to be good reasons for rejecting the generic terms as used in these instances and this topic will be discussed more fully in a forthcoming publication.

[13] The other monolete species of Ibrahim show considerable difference from the form mentioned, chiefly in size, sufficient to suggest that different orders of plants may be grouped together under the original usage. It is hoped that this may be adjusted more satisfactorily in the course of later work.

[14] Sellards, E. H., Codonotheca, a New Type of Spore-Bearing Organ from the Coal Measures. American Journ. Sci. 4th series, Vol. 16; 87-95, 1903.

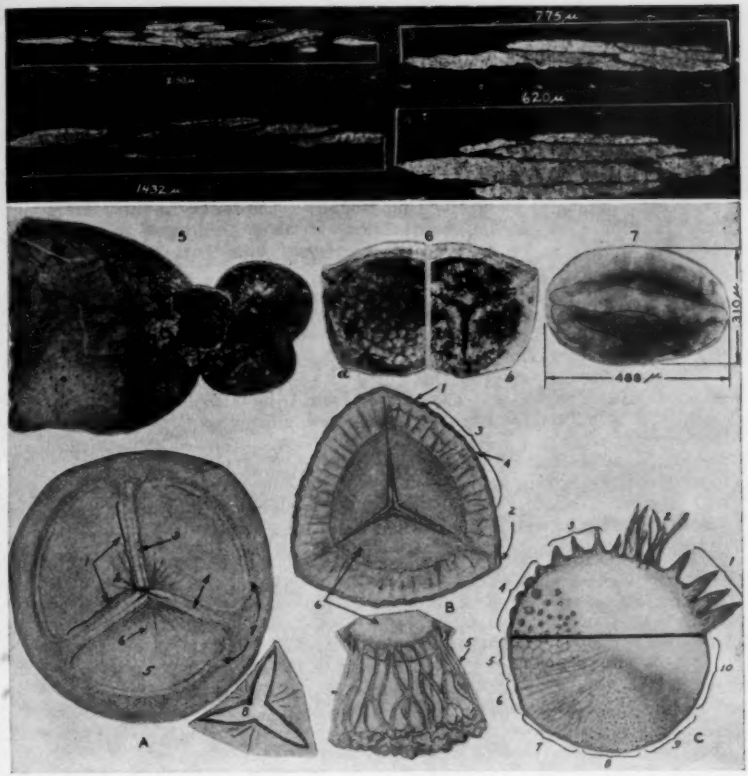
[15] Renault, B. Bassin houiller et permien d'Autun et d'Epinac. Paris, 1896.

[16] Zerndt, Jan, Megasporen aus einem Floz in Libiaz (Stephanien). Bull. Int. de l'Acad. Polon. des Sci. et Lett., Ser. B., (1); p. 55, 1930.

* Sporae ovales longitudinae ca. 450 mu, latitudinae ca. 340 mu, superficibus glabris sed non radiantibus. Proximae superficies tres ostendunt strias longitudinales, quarum duae laterales curvatae, media magis quam ceterae striata. Omnes autem in fine sporae conjunctae sunt. Murus sporae crassitudinae ca. 12 mu.

[17] Wodehouse, R. P., The origin of symmetry patterns of pollen grains. Bull. Torr. Bot. Club 56 (7); p. 340, 1929.

[18] Tammes, P.M.L., On the origin of number and arrangement of the places of exit on the surface of pollen grains. Recueil des Travaux Bot. Neerlandais 27; p. 4, 5 et Seq., 1930.



Figs. 1-4, Synangial groups of microsporangia containing spores.
Fig. 5, *Triletes cf. giganteus* Zerndt. ca. 18 x. Fig. 6, a and b, *Triletes triangulatus* Zerndt.
Fig. 7, *Monoletes ovatus* sp. nov., photograph of Holotype.

Figs. A-C, ASSEMBLED MORPHOLOGIC FEATURES OF TRILETES Reinsch.

Haptotypic Characters*

Fig. A, (all Divisions) TRILETE MARKING
1. RADII
2. APEX
3. LIP
4. SUTURE
5. PYRAMIC AREAS
6. PYRAMIC PLICATIONS
7. ARCUATE RIDGES
8. TRILETE APERTURE

Fig. B, Division *Zonales*
1. EQUATORIAL RIM or FLANGE (produced by super-development of the arcuate-ridges)
2. RADIAL EXTREMITY
3. INTER-RADIAL AREA
4. FLANGE STRIATION
5. ROTATE APPENDAGE (notched rim attached by narrow anastomosing processes)
6. BODY OF SPORE**

Emphytic Characters*

Fig. C, *Apiculati* & *Laevigati*

Division *Apiculati*
1. CLAVUSATE (spiked)
2. HIRSUTE or SETOSE
3. SPINOSE
4. VERRUCOSE

Division *Laevigati*
5. RETICULATE or BIRETICULATE
6. CANALICULATE or STRIATE
7. RUGOSE
8. PUNCTATE
9. GRANULOSE
10. LEVIGATE
    (1) dull
    (2) metallic luster

* Wodehouse, ibid 1929.
** In the division Zonales, markings of the spore body may vary as in the divisions Laevigati and Apiculati.

are often obscured by folds occasioned by crushing, however it is generally possible to distinguish them when observed by means of transmitted light. The central longitudinal striation, in most cases, is clearly made out. The spore wall is quite thin (about 12 mu) and translucent, having characteristically a light yellow to brownish color. The surface is essentially levigate (the folds present being induced in preservation,) with a tendency toward a dull texture although this is not pronounced. When placed in an aqueous medium these spores often swell, seemingly by osmosis, the flattened sides are distended giving the appearance of an inflated football.

When sporangial masses of this *Monoletes* are found in the maceration residues they show an impressed linear striation indicating a sporangial structure similar to, but with a little narrower locule than that possessed by the *Whittleseya fertilis* of Halle.

Undoubtedly, judging from the numbers of individuals of this type seen in residues from this one coal seam in Illinois, this spore represents a vegetation unit of the original flora which was often dominant or co-dominant in the ancient coal swamp.

It has been the object of this paper to show some of the well preserved plant structures which may be obtained from Illinois coals and to indicate a method of scientific treatment from the botanical viewpoint. Paleobotanic treatment of coals is a field which has long been overlooked and which offers an enormous amount of valuable information that bears directly on problems of coal deposition and paleobotany. It is hoped that more investigators will interest themselves in this type of study since the interpretations to be gained can only be well founded when based on a sufficient body of facts.

Germination Behavior of the Rose Mallows

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The genus *Hibiscus* is a wide ranging genus, represented in tropical and temperate floras by almost 200 species including herbaceous annuals, perennial shrubs, and even trees. In North America there are over 20 species, seven of which are found in the region covered by such manuals as Britton and Brown, and Gray. Some of the species, because of their hardiness and large showy flowers, have found favor in cultivation. They are commonly referred to as the Rose Mallows.

The family to which the Rose Mallows belong, the Malvaceae, is listed among those whose species may have macrobiotic seeds, that is, they may remain viable for relatively very long periods in dry storage, or buried in the earth. Such seeds usually have a seed coat which resists penetration by water, and are commonly called "hard" seeds. Other families, including the Nymphaeaceae, Leguminosae, Cannaceae, etc., also possess seeds that do not swell readily on contact with free water.

Various species of the Malvaceae are known to be hard seeded. Thus *Sphaeralcea remota*, formerly known in the United States only from an island in the Kankakee River but now known to have a wider distribution, possesses seeds that will resist entry of water for weeks. Ewart *(2)* lists 15 species of the Malvaceae as macrobiotic, and it is fairly certain that all of these species are more or less hard seeded.

The most common laboratory. treatment used to overcome the hard seeded condition of small seeds is the use of concentrated sulphuric acid (sp. gr. 1.84) for a period long enough to carbonize the cuticular waxes which make the seeds impermeable to water. There is much variation in the length of time that seeds can be treated without being injured. In the case of *Gossypium* whose seeds are not really hard but which germinate more readily if the lint is removed, Miss Brown *(1)* found that 5 minutes is the optimum treatment period for some commonly cultivated varieties. Delinted cotton seeds absorb water more rapidly than undelinted seeds, mainly because the lint holds air and prevents close contact of the seed coat with water. If the treatment is prolonged to 15 or 20 minutes, cotton seeds show some injury which is reflected in slower germination and growth. Raspberry seeds (Rosaceae) can be germinated following sulphuric acid softening of the seed coats, but some varieties will not stand more than 25 minutes, while others require 40 to 45 minutes, or even an hour of treatment to make them permeable to water. If treated too long, all of them are injured.

Miss Jean White *(3)* tested the seeds of four species of *Hibiscus*, and found that the minimum time of immersion in H_2SO_4 to bring about swelling in water was one hour for *H. heterophylla* and *H. lampas;* 25 minutes for *H. tiliaceus;* and 30 minutes for *H. trionum.*

The Rose Mallows were brought to my attention some years ago by a gardener who had found difficulty in germinating the seeds. Knowing the characteristics of the family, the sulphuric acid treatment was employed to induce swelling. Only 79 seeds were available for the first tests, and the varietal name was unknown. The seeds were first placed in germinative

conditions for a few days to determine whether any of the seeds would absorb water. During this period seventeen seeds swelled. When germination ceased, the remaining hard seeds were dried superficially, an operation requiring only a few minutes since the seeds were unswollen, and then submerged in pure sulphuric acid for 5 minutes. The sulphuric acid was then quickly washed off in cold water to prevent heating the seeds which were carefully neutralized and returned to germinative conditions. Eleven more seeds were caused to swell following this single treatment. This procedure was continued until every seed had germinated. At the close of the test, the hardest seed in the lot had been given eleven 5-minute treatments with sulphuric acid before its structures would admit water enough for germination. The results for the entire series of treatments are shown in table 1.

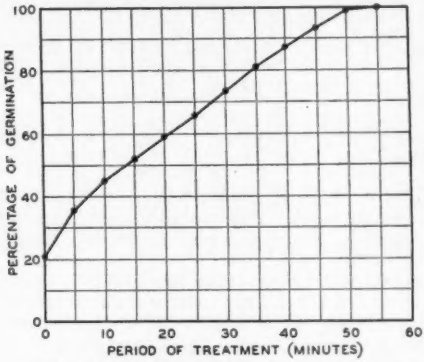

TABLE 1—GERMINATION OF ROSE MALLOW SEEDS FOLLOWING TREATMENT WITH H_2SO_4

Minutes treated	Number germinated	Percentage
0	17	21.5
5	28	35.4
10	35	44.3
15	41	51.9
20	46	58.4
25	52	65.8
30	58	73.5
35	64	81.0
40	69	87.3
45	74	93.7
50	78	98.7
55	79	100

The significance of these results is more readily seen from the graph (Fig. 1) which shows that in a general way the total germination of this lot of hard seeds is a straight-line function of the length of treatment of the seeds in sulphuric acid.*

Since the first experiment, many tests have been run on various strains of Rose Mallows. They are all more or less hard-seeded except *H. africanus*, which gave 100 per cent swelling without treatment. The variety Golden Bowl usually shows a rather small percentage of hard seeds, although this seems to vary with the conditions under which the seeds ripened and from year to year. In some tests of Golden Bowl as many as 75 per cent were not hard. In Moscheutos Rose, 90 per cent of the seeds required treatment. In one lot of Crimson Eye only about 1 per cent of the seeds swelled without treatment; the other 99 per cent were so impervious that selected groups of them could be kept immersed in water for weeks without any gain in weight.

The efficacy of the sulphuric acid treatment on these exceptionally hard-seeded forms is indicated by the fact that Moscheutos Rose and Crimson Eye germinated to 98 and 99 per cent, with treatments of 45 and 55 minutes respectively in pure sulphuric acid.

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* More recent experiments show much irregularity in behavior. The data presented here show a condition not commonly found in large scale experiments.

The Range Indicator Method in pH Determinations of Plant Tissues*

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In studying the pH of certain plants, the necessity arose for the determination of the hydrogen ion concentration of specific tissues within the plant. The variation of the pH from tissue to tissue makes it possible that a mixed liquid expressed from a heterogenous mass of tissues might be misleading in any interpretation of the physiological aspects of the tissues in question. Thus some experiments were conducted with the range indicator method to determine if this method was applicable to the problem at hand and to determine its practicability and objectivity in the hands of the casual worker. Some few results will be given to illustrate the efficiency of the tests.

The methods as given by Small *(1)* were used with minor variations. Table 1 lists the indicators used with their range as determined by means of the potentiometer with well buffered solutions. In each case the pH listed represents the definite appearance in a very thin layer of solution of the color which is indicative of the pH in question. Variation from the standard ranges is due to the use of this thin layer instead of the ordinary test tube method. Solutions of indicators used were .02-.04 per cent in 5 per cent alcohol. Freehand sections of fresh tissues were used and checked with control sections for natural coloration. Examinations were made with artificial light. A Corning glass globe with a clear, blue Mazda lamp of 75 watts was used as a source of light.

Since this method of pH determination seeks to determine the approximate range, only certain definite colors were recorded and used. These colors were the end points as determined on the potentiometer and the ranges were computed accordingly. No arbitrary ranges were set. It was found possible to distinguish the ranges of pH as shown in Table 2. Other plants were used and many variations were noted.

Difficulty was experienced in determining with exactness the presence of some yellows due to the masking influence of chlorophyll and the tendency of yellow to appear colorless when diluted. There is a variation in the quality of yellow obtained with the different indicators. Blues offered the same difficulties. In general, it is necessary to develop a subjective evaluation of the colors involved which is gained through experience. Although it was found possible to determine differences of pH provided they were of considerable magnitude, no satisfactory determinations of small differences in pH were possible. Results cannot always be checked accurately but certain definite variations in the pH of the various tissues within the plant can be clearly noted. The efficacy of the method is doubtful in the hands of an untrained observer. It can however be used easily in the determination of the pH of liquids such as water, and series of indicators can be arranged to suit the needs of the investigator for such determinations.

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* Contributions from the Biological Laboratories of Knox College No. 47.

(1) SMALL, JAMES. Hydrogen-ion Concentration in Plant Cells and Tissues. Protoplasma Monographien II. Berlin, 1929.

TABLE 1—RANGES OF INDICATORS USED IN DETERMINATION OF THE pH

Indicator	Alkaline color	pH	Acid color	pH
Brom-phenol blue	Blue	> 3.6	Yellow	< 3.2
Brom-cresol green	Blue	> 4.7	Yellow	< 3.8
Benzene-azo-α-naphthylamine	Yellow	> 4.8	Red	< 4.2
Alizarin red	Purple	> 5.0	Yellow	< 4.9
Brom-cresol purple	Purple	> 6.2	Yellow	< 5.2
Methyl red	Yellow	> 5.8	Red	< 5.2
Di-ethyl red	Yellow	> 6.1	Red	< 5.4
Brom-thymol blue*			Yellow	< 6.0

* No ranges higher than 6.0 in this series of tests.

TABLE 2—RANGE OF pH IN TISSUES OF LYCHNIS DIOICA L

Tissues	pH Range	Tissues	pH Range
Ovary		*Stem*	
Placenta	4.1-4.8	Epidermis	App. 3.8
Vascular strands	4.8-5.2	Cortex	3.8-4.8
Ovules	4.8-5.2	Sclerenchyma	3.7-4.1
Exocarp	App. 4.8	Pericycle	5.2-5.9
Mesocarp	App. 4.8	Phloem	5.8-6.2
Endocarp	4.8-5.2	Xylem	3.7-4.1
		Pith	3.8-4.8

The Status of the Southern Shortleaf Pine in the Northwestern Ozark Region

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The presence of the southern shortleaf pine, *Pinus echinata* Miller, in the southwestern part of the central hardwoods region provokes a number of questions. Is it a component of a mixed forest of the region? Is its status established, or is it encroaching upon or being supplanted by, the deciduous species? If it is now encroaching, is it destined to become an important or dominant tree? If it is being supplanted, was it in remote times a dominant species? What was the nature of its initial invasion; as a member of a small group of pioneers, or as a single-species migration?

Present distribution.—The southern shortleaf pine occurs from the south Atlantic states to eastern Texas, northward through eastern Oklahoma, northeastward across Missouri to southwestern Illinois, through southern Kentucky, West Virginia, to Staten Island (Sargent, 1922). In the southern part of its range it is a common tree, occurring in pure stands, which are usually "old fields" or "hurricane forest" (Turner, 1935), or as a part of various hardwood complexes. From the Arkansas River northward its occurrence is progressively erratic, with the exception of one area of essentially continuous distribution in north central Arkansas. West and north of there it is found in small, isolated areas separated by thirty to fifty miles of upland deciduous forest and agricultural land (Palmer, 1921). Typifying this condition are the small stands in Union and Randolph counties in Illinois which are also the northernmost extension of the range of the species in this immediate longitude.

In the northern Ozarks it commonly occurs on the south slopes of mountains whose north slopes are occupied solely by deciduous trees. On these south slopes it is usually associated with *Quercus stellata*, *Q. marilandica*, *Q. velutina missouriensis*, *Ulmus alata*, *Juniperus virginiana*, *Bumelia lanuginosa*, *Hicoria buckleyi arkansasa* and *H. villosa*. Less commonly it occurs on east and west but rarely on north slopes. Pure stands are rare and are probably in most cases "old field" or stands established after clearing, heavy lumbering, or tornado.

Success of reproduction.—For the most part natural reproduction occurs only in openings, clearings, abandoned fields or pastures that are not heavily grazed. It seems unable to invade even relatively undisturbed forest, whether deciduous, pine, or mixed. However, pine reproduction of all ages has been observed in openings and clearings where sprout and weed competition are not severe. Deciduous tree reproduction is fairly common in older pine stands.

Artificial plantings of one or two-year-old seedlings in the Ozark and Ouachita National Forests and at the University of Arkansas Experiment Station have met with only fair success, for they have high mortality rates unless weed and sprout competition is reduced and grazing animals are excluded. This means that the plantations must be recently abandoned pastures or fields, and that they must be fenced. Even under such conditions about fifty per cent survival is the best that has been attained to date.

Rate of growth, size, and length of life.—This species probably has a more rapid rate of height growth than associated species. It usually grows

taller than the scrub oaks and winged elm and as tall as the red, black, and white oaks and others. The age of some pine trees in this region has been determined to be from 150 to 200 years. In general, the life span of the shortleaf pine compares rather favorably with but is probably somewhat less than that of some of the deciduous species.

Adaptibility.—Data on this pine's adaptability are meager. Apparently, however, it is not much more or less successful than scrub oaks, winged elm, or red cedar in occupying steep, exposed, rocky or otherwise severe sites. In this pioneering capacity, like the deciduous species mentioned, it is, of course, better adapted than the red and white oaks, red maple, shell bark hickory, and others. Although the pine seems to better hold its own on the south slopes, there is not much evidence that it could remain a dominant tree there, except on rocky, very steep situations.

Winter injury to seedlings.—In two of the previous three years severe injury to and considerable mortality of shortleaf pine seedlings was recorded at the University of Arkansas Experiment Station. Injury occurred to young trees in late winter during periods of freezing weather following several days of weather warm enough to initiate succulent growth. To what extent this functions against the species in nature is unknown, but it may be an important factor.

Prehistorical status as related to present performance.—Data regarding this question as it applies to exactly this region are lacking. However, pollen analysis of peat in the Little Rock region (Sears and Couch, 1932) indicates increasing importance of the species at that spot. This is at the southern edge of the region in question and nearer the described area of continuous distribution in north central Arkansas. Observations of Professor Sears on the present distribution of the pine in Oklahoma, and his recent study of pollen in silts from an ancient lake near the mideastern edge of Oklahoma suggest current invasion of that state from southeast to northwest.

Discussion.—The occurrence of small, widely separated stands of southern shortleaf pine in the northwestern Ozark region suggests previous wider distribution and subsequent diminution. It seems improbable that its fruits were blown or carried over distances that exist between present day stands.

The original, or post-glacial invasion of the species into this region must have been under somewhat more favorable circumstances than now obtain, such as the absence of competing deciduous trees, or climatic conditions more favorable to pine than deciduous species, or both of these features. Presumably it entered the region either as a single, pioneer species invading an unforested area, or as a co-pioneer accompanying such species as *Juniperus virginiana* and *Ulmus alata* and ecologically equivalent species.

It is the opinion of the author that the shortleaf pine is waning in northern Arkansas, southern and eastern Missouri, and southern Illinois. This reduction in area occupied has probably been going on slowly; apparently the margin of advantage of the deciduous trees is not great. Doubtless in some areas more favorable to the pine it may hold its own for many centuries, or indefinitely. Its relatively rapid rate of growth, great motility of fruits, and fair success in reproducing itself in clearings will aid in this. On the other hand it seems certain that its area of occupation will not increase unless favored by some circumstances not now operative.

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PAPERS IN CHEMISTRY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The nine papers comprising the program of the Chemistry Section were all read at the meeting and all but one are here represented.

"Economic Advantages of Water Softening," by A. M. Buswell and W. H. Hudson, State Water Survey, Urbana, was not presented for publication.

Attendance at the meeting averaged fifty-five; maximum attendance was seventy.

Dr. John H. Reedy, Department of Chemistry, University of Illinois, was elected chairman of the Chemistry Section for the year 1935-36.

(Signed) FRED A. DYKINS, *Chairman.*

The Detection of Fortification or Adulteration of Meat Broth With Monosodium Glutamate

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One of the more recent additions to the group of food seasoning materials is monosodium glutamate. Han *(1)* has given an account of the rapid commercial development of the new chemical condiment in the Far East. Large quantities of the material are now being shipped to the United States, particularly one product of Japanese origin known as "ajinomoto", or in English "essence of taste." Ajinomoto is a white powder which is quite stable under atmospheric conditions. It has a very faint odor and the taste in proper concentration is described as "that of the red juice from roast beef, salty, meaty and appentizing" *(2)*.

It is believed that several manufacturers have found it profitable to use the artificial flavoring substance in place of pure meat broth. The matter was brought to the attention of the writers and a request made that some method of testing be worked out whereby adulteration could be detected.

To establish adulteration, information must be available as to the average composition of samples of known purity so that a comparison can be made with the composition of non-genuine products and relationships found which are indicative of the fraudulent or unfair practice. An effort was made to secure information of this character. Samples were furnished by an interested manufacturer and considerable analytical work was carried out. The constituents determined and the values obtained are indicated in Table 1. Official methods *(4)* were used. All estimations were made on the liquid portion of the broth from which the suspended solids had been filtered with the aid of Filter-Cel.

An examination of the table shows that the amounts of all constituents in the simulating samples (G and H) is much lower than in the genuine products. If more ajinomoto is used to raise all the values, the ratio (g) of amino nitrogen to total nitrogen, will be increased beyond the normal average. The probability of the clever addition of other materials must also be anticipated. Perlman *(5)* suspecting the use of certain vegetable extracts and wheat gluten products in bouillon cubes has suggested the ratio of alkalinity of ash (as Na_2CO_3) to the total ash as a means of detection. For broth this ratio is not as significant as the alkalinity value (c) itself. The addition of rice to the broth apparently has but little influence upon the soluble fraction. One very interesting feature is that the genuine and modified samples have a rather constant ratio (h) of alkalinity of ash to amino nitrogen.

Attempts were made to determine the actual amount of glutamic acid by the method of Plimmer *(6)* but it was found that the presence of other constituents of the broth interfered with the precipitation of the zinc glutamate. The procedure of Kingston and Schryver *(3)* was also unsatisfactory for the broth.

With the accumulation of more data, the inclusion of other determinations and evaluation of new constants, it is believed that any improper use of ajinomoto may be satisfactorily determined.

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TABLE 1—COMPOSITION OF GENUINE AND MODIFIED CHICKEN BROTH

Values Expressed in g. per 50 cc. of Liquid Fraction

Nature of sample	Sample number	(a) Total solids	(b) Ash	(c) Alkalinity of Ash as Na_2CO_3	(d) Ratio c/b	(e) Total Nitrogen by Kjeldhl	(f) Amino Nitrogen Van Slyke	(g) Ratio f/e	(h) Ratio c/f
Genuine chicken broth with rice added.	A	1.304	0.5207	0.0388	0.074	0.1160	0.0160	0.137	2.42
	B	1.012	0.4591	0.0475	0.103	0.0728	0.0175	0.239	2.71
	C	2.057	0.5804	0.0406	0.070	0.2338	0.0203	0.087	2.00
	D	1.861	0.5384	0.0437	0.082	0.1948	0.0206	0.105	2.12
	E	1.618	0.5347	0.0417	0.078	0.1710	0.0206	0.120	2.02
Pure chicken broth	F	1.408	0.5160	0.0248	0.053	0.1368	0.0175	0.127	1.98
Modified broth	*G	0.881	0.4531	0.0189	0.042	0.0680	0.0098	0.145	1.92
	**H	0.653	0.3905	0.0135	0.032	0.0415	0.0070	0 168	1.93

* Sample G {50 per cent genuine broth. {50 per cent solution of 0.8 per cent NaCl and 0.3 per cent Ajinomoto.

** Sample H {25 per cent genuine broth. {75 per cent solution of 0.8 per cent NaCl and 0.23 per cent Ajinomoto.

Reactions in Fused Pyridine Hydrochloride

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Water alone can no longer be considered the only solvent capable of serving as a reaction medium. The researches of Franklin,[1] Kraus, Walden,[2] and others have shown that numerous solvents yield conducting solutions; and that all substances exhibit solvent properties to a greater or lesser degree. Consequently, it has been found necessary to make decided changes with respect to the definitions of certain classes of compounds in terms of the solvent employed. Compounds ordinarily regarded as salts in the aquo-system have been found to behave as acids or bases in other non-aqueous solvents.

Thus, ammonium salts behave as ammono-acids in liquid ammonia as the solvent,[3] whereas acetates react as aceto-bases in glacial acetic acid.[4] In liquid ammonia, an ammono-base such as sodium amide, $NaNH_2$, reacts readily with an ammono-acid such as cyanamide, H_2NCN, to yield a well-defined salt, in this case sodium ammono-carbonate, Na_2NCN. Similarly, salts of hydrazine and hydroxylamine behave as acids in hydrazine and hydroxylamine, respectively. "Onium" salts, in general, exhibit acidic characteristics in the corresponding anhydro-bases as solvents. An extension of this concept to other solvents has revealed the existence of numerous compounds which may serve as parent substances for solvo-systems of acids, bases, and salts.[5] Since the number of such solvo-systems could be increased without limit, it soon became obvious that confusion would result, particularly with respect to nomenclature.

Brönsted brought order in this chaotic field by proposing a general theory of acidity.[6, 7] The phenomenon of acidity is simply a matter of competition between the solvent and the acid anion as bases for the proton. Acidity in basic solvents is, therefore, due to the formation of the corresponding "onium" ions. In ammonia, there is formed the ammonated hydrogen ion or ammonium ion, which is the bearer of acidity. In aniline, it is the anilinium ion, $C_6H_5NH_2.H^+$; in hydrazine the hydrazinium ion, $N_2H_4.H^+$.

The question naturally arises: Do "onium" salts in the solid and fused state, in which the "onium" ion must of course exist, also exhibit the properties of acids? Are these compounds a distinctive class of acids, per se? The chemical behavior of fused pyridine hydrochloride conclusively proves that this is true. All other "onium" salts, thus far investigated, have been found to behave in a similar manner.[8]

Preparation of pyridine hydrochloride.—Because of the hygroscopic nature of pyridine hydrochloride, the anhydrous salt was always prepared just before use. Three useful methods of preparation were developed: (1)—Hydrogen chloride gas prepared in a Kipp generator by reacting concentrated sulfuric acid with ammonium chloride is dried by passing through two gas-washing bottles containing concentrated sulfuric acid and then introduced into a solution of pyridine in dry ether. Pyridine hydrochloride precipitates immediately as a white salt. Pyridine must be present in excess in order to prevent the formation of pyridine dihydrochloride. The salt is filtered in

a Buchner funnel, washed with dry ether and kept in a vacuum desiccator over anhydrous magnesium perchlorate. (2)—Concentrated hydrochloric acid is added to a slight excess of pyridine and the resulting aqueous solution of $C_5H_5N.HCl$ distilled. The distillate which comes over at 218-218.5°C. is collected as pyridine hydrochloride. The solidified salt is dissolved in absolute alcohol and crystallized by cooling. The salt remaining in the mother liquor may be precipitated with dry ether. (3)—Anhydrous ether is saturated with dry hydrogen chloride gas and placed in a separatory funnel. This solution is slowly added to pyridine until precipitation of pyridine hydrochloride is almost complete. The melting point of pyridine hydrochloride prepared by any of these methods was found to be approximately 143-144°C.

Reactions in fused pyridine hydrochloride.—Metallic oxides such as CuO, BaO, MgO, PbO, Fe_2O_3, etc., dissolve in the fused salt to give the corresponding metallic chlorides, pyridine, and water:

$$MeO + 2C_5H_5N.HCl \rightarrow MeCl_2 + 2C_5H_5N + H_2O$$

Oxides of tungsten, tantalum, thorium, titanium, and tin do not react. V_2O_5 and MoO_3 dissolve to form compounds whose compositions have not yet been determined.

Many metallic chlorides dissolve in fused pyridine hydrochloride in most cases with the formation of double-salts, which may be recrystallized as such from various solvents.

$$xC_5H_5N.HCl + yMeCl_2 \rightarrow yMeCl_2.xC_5H_5N.HCl$$

Active metals dissolve to give hydrogen, pyridine, and the corresponding chlorides.

$$Me + 2C_5H_5N.HCl \rightarrow H_2 + 2C_5H_5N.HCl + MeCl_2$$

Silver and arsenic were found not to react with the fused solvent.

Many carbonates, hydroxides, nitrates, sulphates, and acid salts were also found to be soluble.

Electrolyses in fused pyridine hydrochloride.—Fused pyridine hydrochloride and the fused double salts of which a great many are noted in the literature were found to be good conductors of electricity. However, electrodeposition of metals from such low temperature melts is somewhat limited. The less active metals, arsenic, bismuth and antimony could readily be discharged in the form of good, crystalline deposits. Hg collected on the cathode in the form of small globules. Cobalt gave a lustrous plate while tin deposited in the form of loose, metallic flakes. Attempts to plate W, Mo, V, Mn, Cr, Al, Fe, Zn, Pb, and Mg were unsuccessful.

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Some Tests for Metal Ions Making Use of Organic Dyes

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The idea of testing for metallic ions by means of organic dyes and other organic compounds is by no means a new one. A number of current qualitative analysis texts make use of a few such tests. Aluminon seems to be considered quite a satisfactory test for aluminum *(1)*. Dimethyl glyoxime has a wide use in testing for nickel. Likewise the Titan yellow test *(2)* the Clayton yellow test *(3)* and the p-nitro benzene azo resorcinol test known as the " & O" test *(4)* are all being used to detect or confirm magnesium. Also there is quite a long list of similar tests that have been observed but which do not seem to have come into any general use.

It was with the thought of extending the list somewhat and the hope of finding some new rather distinctive tests for metals where needed, that this short and by no means exhaustive study was made at Greenville College as an honors project by a senior major student in Chemistry.

In general, the procedure was simple and consisted in adding a few drops of the dye solution to a five cc. portion of a solution of the metal salt then precipitation of the metal as the hydroxide, carbonate or sulphate.

A relatively small number of dyes was used in these tests, only those which happened to be readily available, ie, aluminon, amaranth, malachite green, aniline yellow, congo red, Clayton yellow, fluorescein, indigo carmine, methylene blue, methyl orange, methyl violet, naphthol yellow S, light green S. F., orange I, ponceau 3R, rosaniline, erythrosin, and picric acid.

Out of the three hundred, or so, possible combinations using one dye and one cation at a time there were three rather distinctive color effects obtained which were not found to have been observed and recorded. These are as follows: a fluorescein test for lead, a fluorescein test for silver, and a naphthol yellow S test for stannous tin. A more detailed description of each follows:

Fluorescein test for lead.—To five c.c. of solution containing lead ions are added two drops of a saturated fluorescein solution in equal parts of water and methyl alcohol. Ammonium hydroxide or sodium hydroxide is then added dropwise until precipitation results. A pink coloration usually appears at once. The pale pink or rose colored precipitate soon settles out. If no interfering ions are present the supernatant liquid usually remains the bright yellow color of fluorescein in alkaline solution. This test is sensitive to the extent of one part of lead nitrate to five hundred parts of water in absence of other ions. It is quite satisfactory even in presence of other cations, provided they are not present too greatly in excess of the lead. For instance, mercurous and some colored ions such as ferric iron or copper in appreciable quantities obscure the pink color. In presence of some ions as aluminum, magnesium and antimony the pink color appears immediately

(1) J. A. C. S. 49:2395 (1927) (Yoe and Hill).
(2) Biochem. Z. 185:344 (1927) (Kolthoff) C. A. 21:2632 (1927).
(3) J. S. African Chem. Inst. 11:67 (1928) C. A. 23:1838 (Barnes).
(4) J. A. C. S. 51:1456 (1929) (Ruigh).

on the addition of the reagent, but on standing it tends to be obscured by the other precipitates. It is rather striking that even in presence of some colored ions such as cobalt the pink lead hydroxide settles out when an excess of ammonium hydroxide is added.

Fluorescein test for silver.—The only insoluble carbonate that seemed to adsorb any of these dyes to give any distinctive test is that of silver which also adsorbs fluorescein. The test is performed as follows:

To five c.c. of a dilute solution of a silver salt one or two drops of a saturated solution of fluorescein in a water-alcohol mixture are added and then 4 N sodium carbonate solution added drop by drop. Much care must be used in order not to add too much reagent, as an excess will destroy the color. A pink or rose colored precipitate will settle out. The question naturally arises here whether the precipitate adsorbing the color is a carbonate or an hydroxide. To attempt to precipitate silver hydroxide by the addition of an ordinary solution of sodium hydroxide or ammonium hydroxide always produces a black, silver oxide almost immediately. However, on the addition of calcium hydroxide to the silver solution containing fluorescein there appears to be formed a colloidal suspension of silver hydroxide which has absorbed the dye in the usual manner, imparting the pink color to the entire solution. Also, when a one-tenth normal ammonium hydroxide solution is used, a similar appearance results. In time these two gradually darken and settle out, evidently as silver oxide. This test will detect silver when it is present in one part to five hundred parts of water. This test is satisfactory in the presence of some other metal ions, the pink precipitate settling out and leaving the yellow fluorescein solution above or a mixture of the precipitate of the other metals present. However, the colorless ions—mercurous, mercuric, stannous, stannic, ferrous and some colored ions, such as ferric and nickel do interfere with this test. In the main the interference is evidently due to the interfering ion reducing the silver to black, finely divided metallic silver. Ammonium ions in all concentrations, and alkali metals in high concentrations seem to interfere with this test.

A naphthol yellow S test for stannous tin.—If two or three drops of a 2 per cent solution of naphthol yellow S are added to a stannous salt solution and then sodium hydroxide added drop by drop, the color of the solution will change to a bright red-orange or pink. In absence of other cations this test is sensitive in solution containing one part of stannous to two thousand parts of water. However, in the more dilute solutions it is advisable to compare the solution with a blank, otherwise the slight color change cannot be detected. It should be noted that it is not a matter of the precipitate absorbing the dye, as in the two cases of fluorescein which have been described, but rather the color appears more especially in the solution when the amphytoric hydroxide has dissolved in an excess alkali.

Obviously, this test would be of no value in the presence of such metals, as mercury bismuth and silver, whose hydroxides are easily reduced to the colloidal metallic state by the sodium stannite present. Neither will it be of much value in the presence of the colored ions. A striking exception to this is seen though in the case of a dilute copper solution where a good orange color appears. It seems to work satisfactorily in presence of all other ions except that some care must be exercised in those cases where a heavy precipitate is being formed. However in the case of a heavy precipitate of lead chloride the color test is quite sensitive. In the presence of manganese the color is more of a violet, while with magnesium it is of an orchid tinge. The same test may be observed by using ammonium hydroxide or sodium carbonate, although it seems to be more delicate in the presence of sodium hydroxide.

Some Physiological Responses to Vitamin E Feeding

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Probably the most remarkable results of nutrition research during the past decade have been the repeated demonstrations that mammals generally can be reared successfully on simplified dietary mixtures consisting of protein, fat, carbohydrate, mineral salts, and the heretofore known vitamins, particularly A, B (complex) and D, and that although completely normal adulthood is reached the animals sooner or later show a lessened sex urge and lose entirely the power to reproduce. They become sterile.

Aside from the tremendously significant potential therapeutic application of these results to the human, the application to livestock breeding is economically important at this time, and in addition, the byways that are opened up during the more minute study of sterility, lead to findings that profoundly affect genetecists and others.

Vitamins A and B have always been associated with reproduction physiology but even the very great increase of these vitamins in the diet failed to prevent or to cure sterility *(1)*. Finally Evans and his associates clearly established the existence of another fat soluble, Vitamin E and its indispensable relation to fertility *(2)*. Reviews clearly indicate that insofar as reproductive physiology is concerned Vitamin E is absolutely indispensable, and that whereas Vitamins A and B contribute considerably to heightened reproductive ability, unquestionably the combination of Vitamins A, B and E are decidedly more effective. Viewed from this point, the present day vitamin combinations prescribed so freely by physicians are physiologically justifiable but nutritionally incomplete. The omission of Vitamin E is unsound and unnecessary.

Whereas Vitamin E affects particularly the tissues of the foetus and is therefore gaining considerable importance as an element for foetal infectious susceptibility that makes for abortion in cows, and whereas Vitamin E stands in many intimate correlations with animal feeding in offsetting the positively harmful effects of cod liver oil alone, this occasion does not permit of an exhaustive review of the many responses that are obtained by the feeding of Vitamin E. I have chosen to discuss one type of response that is particularly intriguing and that has to do with the artificial control of sex in which Vitamin E appears to be in some way implicated.

The experimental technic was simple. Rats of known strain such as have been bred for use in our laboratories for more than eight years were kept on a balanced stock ration of usual composition.

In place of lard we preferred to substitute refined linseed oil to insure the presence of the indispensable unsaturated fatty acids, linoleic and linolenic. Proper amounts of Vitamins A, B (complex) and D were easily furnished through present day concentrates. Our only difficulty was the insurance of biologically active Vitamin E source for which after several years of experimenting we selected cold pressed wheat germ oil, obtained from fresh germ to avoid losses due to rancidity. Solvent-extracted oils were

thoroughly unreliable in potency, and if potent, in stability. Curiously enough many writers on nutrition dismiss the subject of Vitamin E by admitting its existence and then implying that its widespreadness makes it unimportant. We thoroughly disagree with these unsupported speculations. Our finding is that Vitamin E is not nearly as widespread in sufficiently abundant amounts to prevent nutritional sterility and that anything having to do with reproductive regulation is far from unimportant. Thus, breast milk, like cow's milk, is exceedingly deficient in Vitamin E; so that sucklings dependent upon mother's milk for nutrition are threatened with the ill consequences of Vitamin E deficiency from birth. And some of these ill consequences, like male sterility, are irrevocably irreparable.

In over 7,000 experiments, our findings disclose that if male rats are kept on a diet adequate in every known respect but low in Vitamin E, the litters which they father are small in number and show a sex ratio in which the males are as low as 80 to every 100 females.

If the males are kept on a vitamin E rich diet, they father litters of average normal number and show a sex ratio in which the males exceed the females in the proportion of 110 to 100.

If both the males and the females are kept on rich vitamin E diets, the litters are about of average normal size and the sex ratio reaches as high as 130 males to 100 females.

It is unfortunate that in a brief presentation only a summary of the findings can be submitted. It is desired to indicate, however, that the effect of seasonal incidence on the sex ratio of the rat is thoroughly well known and that the sex ratios which have been presented are the averages inclusive of all the variants excepting the variant of regulated diet.

An interpretation of the observations is considerably more difficult. Such factors as selective mortality must be considered; but when the number of animals in the litters are consistently equal, and yet the ratio of males over females significantly increases, the matter of selective mortality hardly suffices by way of explanation.

There can be little doubt that the chromosomes must receive their nourishment from the nuclear material in which they are imbedded, and it would seem reasonable to assume that if the nutritional pabulum of the chromosomes is profoundly altered, some measure of differential viability might be conferred on the sex-determining chromosomes.

It is perfectly well agreed that there are two kinds of sperms, the Y-bearing or male producing, and the X-bearing or the female producing, and that these exist in millions and in practically equal numbers. It is further assumed that it is largely a matter of chance as to which one reaches the ovum first.

It appears certain, also, that males are more susceptible than females to the vicissitudes of early development and that the general sex ratio of about 105 males to 100 females at birth can be greatly altered by favorable conditions of life.

Some author has said that "if we could discover some anesthetic subtle enough to paralyze one kind of sperm and not the other, voluntary sex determination would soon be a practical possibility." Nothing of the sort has thus far been found; but it is theoretically possible, for the two kinds of sperms must be somewhat different and it would be silly to declare success impossible.

Our experiments are entirely too few to warrant even a suggestion of hope in this direction; but they are sufficiently significant to stress the imperative necessity of vitamin E in the fundamental restoration of viable strength to the male sperm which is notoriously feeble as compared with the female sperm.

An Inexpensive Ball Mill for General Use

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A ball mill is a very useful and much needed piece of apparatus in most chemical laboratories. It is also a type of apparatus which is not in continual use except in those laboratories where the research or class work involves the use of considerable quantities of finely powdered materials. In these same laboratories it may be necessary, at times, to grind small, and at others, to grind relatively large amounts of materials. Most ball mills in general use will hold but one sized jar, unless an adapter is used to hold small jars in the larger machines.

In order to have a ball mill which would be fairly inexpensive, which would not occupy too much floor space, and which could be used for ball mill jars or other containers of various sizes, the ball mill shown in the accompanying illustration was designed.

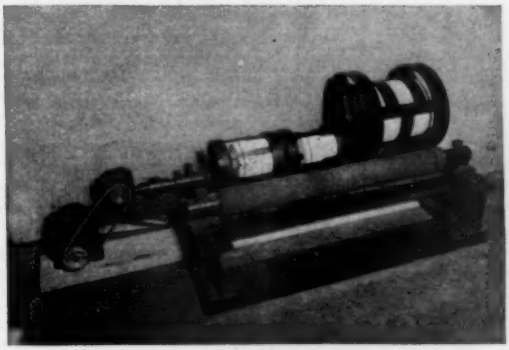

Fig. 1.—Ball mill.

The principle of the device is simple. There are two rollers on which the racks for the ball jars or other cylindrical objects may be placed. One of the rollers is connected to a motor, and may be designated at the "power roller". The other roller is free to rotate as it will. In the photograph the rear roller is connected to the motor through a speed reducer (20:1 ratio) and an ordinary V-belt. The front roller is the "idler". Both rollers were made from 3-inch pipe, into the ends of which plugs were screwed. Pieces of steel rod were inserted in each plug to serve as the bearing axles for the rollers. The bearings for these axles are ordinary brass bearing supports for holding the usual babbitt bearing metal. To increase the friction between the rollers and the racks for the jars, a piece of automobile inner tube was pulled over each of the rollers. This method permits the rubber surface to be replaced as often as needed and with the minimum of expense.

In the illustration, the support for the rollers is shown as pieces of I-beam. They are about two feet long and the distance between them is about three feet. The supports could be made from pieces of timber, railroad rail, or other strong material if I-beams were not available. It can readily be observed that each of the pieces of I-beam has a series of holes drilled in the upper surface. The two bearings for the "idler" have a pair of pins projecting from their lower surfaces. It is therefore possible to regulate the distance between the rollers by placing the pins in the proper set of holes. In the diagram, the rollers are close together as when used for the smaller jars.

The racks for holding the ball jars were also made from inexpensive and easily obtained materials. The rings for the racks were made from water pipe of suitable diameter. For the small jars shown in the illustration, 6-inch pipe was used, and for the large ones, 12-inch pipe. (The small jars have about one liter capacity, the large ones, 6½ liters.) The rings for the large jars are held apart by two pieces of T-iron, which act as the supports for the metal straps holding the jar in the rack. The rings for the small jars are held apart by ½-inch strap iron. One end of the small racks is partially closed by a cross of the strap iron. The jars are held in these small racks by the same device which holds the cover of the jar in place. This device consists of a screw passing through a small rod of iron or steel. When the rod is placed against one of the rings, the screw may be turned down against the cover of the jar, and the jar against the cross closing the other end of the rack, thus holding both the jar and the cover in their proper places.

Since there is an optimum speed for obtaining the best grinding results for different sized containers, this particular mill was driven by a direct current motor, the speed of which can be varied by a rheostat. If only one sized jar is to be used, the variable speed control is not necessary. The best speeds are from about 30 to 75 r. p. m., depending on the diameter of the object being rotated. The length of the rollers may be several feet if desired.

The ball jars used for this mill were purchased from the Ceramics Department, University of Illinois. The actual construction of the machine was done by Arthur E. Wood, mechanician for the Chemistry Department. The cost of materials, which included three small jars and two large jars was about thirty-five dollars.

Illinois Fluorspar as a Chemical Raw Material

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Fluorine is the most electro-negative of all the elements. For years its tremendous reactivity was a barrier that resisted the efforts of the most capable investigators to isolate this element. Although Henri Moissan in 1886 finally succeeded in preparing gaseous fluorine by electrolysis of potassium acid fluoride, the reactivity of the element and the resulting difficulties in handling it, have prevented completely the commercial utilization of fluorine.

However, certain inorganic fluorine compounds have been of considerable industrial importance for years. Calcium fluoride in the form of the mineral fluorite is the most important because of its availability as a flux and chemical raw material. Among the other inorganic fluorides of commercial importance are those of sodium, potassium, barium, and zinc, and the corresponding silico-fluorides which are used as insecticides and preservatives. The acid fluorides of sodium and ammonium find use in the laundry and textile industries. A few years ago an organic fluorine compound, dichlorodifluoro methane (commercially known as Freon), came upon the market as a new refrigerant with many desirable properties. Since then many other commercially valuable organic fluorine compounds have appeared and a new industry appears in the process of development.

It is well, therefore, to consider (1) the mineral sources of fluorine in the earth's crust, (2) the present markets for fluorine-containing compounds, and (3) the direction which further utilization of fluorine compounds will probably take.

The three principal sources of fluorine today are (1) fluorapatite ($CaFCa_4(PO_4)_3$) in phosphate deposits containing 3.5 per cent fluorine; (2) the mineral fluorite (CaF_2) containing 48.5 per cent; and (3) the mineral cryolite (Na_3AlF_6) containing 54 per cent fluorine.

The world's phosphate deposits contain the greatest known reserves of fluorine. However, with the exception of fluosilicic acid which is a by-product in the manufacture of acid phosphates, recovery of the fluorine in a usable form is difficult. This by-product has become a problem and expense to the phosphate producers on account of the limited market for fluosilicates and of the problem of its disposal to avoid stream pollution. Therefore, as a raw material for a fluorine chemical industry the phosphate deposits are of limited value.

The principal raw material from which we now obtain our fluorine containing compounds is fluorite, commonly called fluorspar. That this mineral is widely distributed over the earth's surface is shown by the production of over 2,500,000 metric tons from 1922 to 1932, by countries as follows: United States, 42 per cent; Germany, 27 per cent; Great Britain, 15 per cent; France, 7.3 per cent; Italy, 2.4 per cent; Spain, 2.1 per cent; and all other countries, 4.2 per cent. In the United States approximately 80 per cent of the fluorspar produced has been used in the manufacture of basic open hearth steel, 9 per cent in glass and enamel ware, 9 per cent in the production of hydrofluoric acid and derivatives, 1 per cent in foundries, .5

per cent for export and the remaining .5 per cent for miscellaneous uses including optical fluorspar. About 90 per cent of the fluorspar produced in the United States comes from the Illinois-Kentucky mines, Illinois producing slightly more than Kentucky, and accounting for over 1/5 of the total world production.

Since fluorspar deposits vary in purity, it is marketed in various concentrations. The names, uses, and specifications of the three principal grades are: (1) Metallurgical—used principally in the manufacture of basic open hearth steel, contains not less than 85 per cent calcium fluoride and not more than 5 per cent silica; (2) Ceramic—used in the manufacture of glass and enamel ware, contains not less than 95 per cent calcium fluoride and not more than 3 per cent silica; (3) Acid—used in the manufacture of hydrofluoric acid and derivatives, contains not less than 98 per cent calcium fluoride and not more than 1 per cent silica.

The present tariff schedule favors the importation of acid spar to such an extent that it has even been imported for ceramic uses. As most of the acid spar is consumed near the eastern seaboard, the bulk of that consumed is imported. This increases the dependency of the Illinois-Kentucky fluorspar producers upon the basic open hearth steel industry and causes the demand for fluorspar to parallel even more closely the steel production curve.

The third mineral source of fluorine is in the mineral cryolite. Unlike fluorspar, cryolite is not distributed widely in commercial deposits. The only important deposit is in Ivigtut, Greenland, and is owned by the Government of Denmark, and is distributed in the United States by the Pennsylvania Salt Company. Approximately 5,000 tons per year are imported. One of the principal uses of cryolite is in the production of aluminum from bauxite. Synthetic cryolite produced from fluorspar has replaced a large amount of the natural mineral. The limited supply and high price of cryolite prevent its use as a serious competitor of fluorspar.

From the chemical viewpoint fluorspar enters two fields of utilization. The first of these is as a flux for silicate materials and includes its application in the manufacture of basic open hearth steel, cement, glass and enamels. In this field very little is known concerning the chemistry of the reactions involved and the mineral is used in a purely empirical manner. The second field of utilization is in the chemical industries. Here its use has been delayed due to the difficulties encountered in the manufacture of fluorine derivatives and the lack of information in regard to the properties of fluorine containing compounds. However, during the past five years rapid progress has been made in the industrial synthesis of organic fluorine containing chemicals, particularly refrigerants and dyestuffs. Research in this little known field should produce valuable results and promote a more balanced and diversified market for fluorspar. Concurrently, study of the chemical reactions which take place between fluorspar and silicate mixtures should prove of practical value in putting fluxing operations on a sound scientific basis.

The manner in which the fluorspar deposits are laid down makes impossible an accurate estimate of reserves. However, careful study of this field indicates definitely that sufficient fluorspar can be produced in Illinois in any grade desired to meet the demands of the consuming industries for many years.

Micro Methods in Qualitative Analysis

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Micro analysis seeks to detect very small amounts of unknown substances, either by (1) devising more sensitive tests, or (2) increasing the sensitiveness of old tests by means of improved technique. First among the new tests of high sensitiveness should be mentioned the "spot" tests of Feigl and others, using, for the most part, organic reagents. The chemistry involved is too difficult for students at the time qualitative analysis is ordinarily taken. Chamot has devised microscopic tests, in which derivatives are prepared and identified by their appearance under the microscope. But the work to be presented in this paper is not new reactions, but old reactions done in a new way. It is based upon the work of Behrends, Emich and others, who have shown that the sensitiveness of some of the older reactions may be considerably increased by means of an improved technique. It is proposed to illustrate some of these improvements by the following procedure for analyzing Group I of the cations.

Precipitation of Group I.—A single drop each of 1 per cent solutions of $Pb(NO_3)_2$, $AgNO_3$ and $Hg_2(NO_3)_2$ is introduced into a small test tube, and diluted with 1 or 2 cc. of water. One drop of concentrated HCl is added, and the mixture is whirled in a centrifuge for a few minutes. (*Precipitation by centrifugation.*) The clear supernatant liquid is decanted, and the residue is washed with about 1 cc. of water, introduced beneath the precipitate by means of a pipette, so as to provide good mixing. The precipitate is again settled by means of the centrifuge, and the clear liquid is decanted. (*Washing of precipitates.*) In a complete analysis, these two solutions would be combined and used for the analysis of Groups II-V.

Tests for the Pb^{++} Ion.—The $PbCl_2$ in the residue is extracted by adding 1 or 2 cc. of hot water and stirring the mixture, followed again by centrifugation and decantation. (*Extraction.*) After introducing the hot water, the mixture is stirred by blowing gently through a fine pipette extending to the bottom of the tube. Solutions should not be boiled in small test tubes, since the solution is apt to be completely "bumped out" by the bubbles of steam. Hence the water is heated before it is introduced into the tube. The extract is concentrated in a 2 cc. evaporating dish to about 1 cc. by evaporation over a micro burner, taking care that the solution does not boil over. The presence of the Pb^{++} ion may then be shown by the following tests:

(1) A droplet of the solution is drawn into a capillary tube, followed by a minute amount of K_2CrO_4 solution. This is easily accomplished by touching the end of the capillary to drops of the Pb^{++} and CrO_4^{--} solutions on a microscope slide. The solutions will rise in the tube by capillary action. The $PbCrO_4$ is easily seen at the junction of the two liquids. (*Capillary test.*)

(2) A drop of the Pb^{++} solution is placed upon a slide, and a minute crystal of KI added. A yellow precipitate of PbI_2 forms, which may be recrystallized by warming carefully and cooling. It may be necessary to add a drop of water if the amount of precipitate is large. (*Recrystallization.*)

An alternate form of the test is the addition of the KI to a drop of the solution in a small test tube.

(3) If a drop of the Pb^{++} solution is placed on a piece of thread or string that has been impregnated with ZnS, there appears first a yellow color, rapidly going over into a brown. This color is due to PbS, which may further be identified by examination under a microscope. (*Fiber test.*) The sensitized thread or string is prepared by alternate treatment with $ZnSO_4$ and Na_2S, following by washing and drying. For general use, sensitized strips of filter paper have been found more satisfactory than threads and strings. Asbestos fibers have also been used for this purpose.

(4) A very characteristic test for Pb^{++} is the formation of the triple nitrite, $K_2CuPb(NO_2)_4$, as follows: A drop of the Pb^{++} solution is mixed with a drop of $Cu(C_2H_3O_2)_2$ on a microscope slide, and the mixture carefully evaporated to dryness. After cooling, a drop of a solution made by mixing equal parts of saturated KNO_2 solution and glacial $HC_2H_3O_2$ in *M* $NH_4C_2H_3O_2$ is placed upon the stain, and carefully mixed by means of a glass fiber. A precipitate of black cubes appears, best observed under a lens. (*Slide test.*)

Detection of the Hg_2^{++} Ion.—The residue, from which the $PbCl_2$ has been removed, is dried in the original tube by careful heating on a hot plate or over a micro burner. The condensate on the cooler part of the tube may be conveniently removed by strips of filter paper. The lower end of the tube is then heated more strongly, subliming the Hg_2Cl_2 on the upper wall of the tube. (*Sublimation.*) The part of the tube containing the AgCl is cut off, by scratching with a file and applying a hot end of a glass rod to the scratch. The Hg_2Cl_2 sublimate may be further confirmed by adding NH_4OH, but the black stain obtained is no improvement over the original white sublimate as a test for mercurous mercury.

Detection of the Ag^+ Ion.—The end of the tube containing the AgCl residue is placed in a micro beaker, and the AgCl is dissolved in a few drops of NH_4OH. The solution is transferred to a test tube, and a drop of Na_2SnO_2 added, forming a voluminous black precipitate. (*Reduction test.*) This test is surprisingly sensitive, and will give tests for as little as 30 γ (0.030 milligram) of Ag^+. It is hard to believe that this precipitate consists of nothing but black silver. Probably it contains considerable tin, formed catalytically: $2\ SnO_2^{--} + H_2O \rightarrow Sn + SnO_3^{--} + 2\ OH^-$. This form of test for Ag^+ seems new. Tananaeff has used $SnCl_2$ in a spot test for Ag^+, but no record has been found for the use of Na_2SnO_2.

It should be understood that the above procedure is not the one ordinarily used in a micro analysis of Group I. The usual procedure has been considerably modified and lengthened so as to illustrate several forms of the technique of micro chemistry.

ONIUM SALTS AS ACIDS

Reactions of Ammonium Chloride at Higher Temperatures

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It is a well known fact that ammonium salts when dissolved in liquid ammonia behave as acids, but it has only recently been demonstrated that fused ammonium salts exhibit acidic properties.[2] Thus fused ammonium nitrate reacts with metals, oxides, and carbonates in a manner entirely analogous to nitric acid. The actual bearer of acidity in this case is the ammonium ion, which under the circumstances may release the proton (hydrogen ion). It thus fulfills the conditions postulated by Bronsted[3] who defines an acid as "any molecule or ion which may lose the proton".

Reactions in the solid state are also well known. Since the ammonium ions are present as a definite constituent in the crystal lattices of ammonium salts, it was to be expected that the latter might under proper conditions react as acids even in the solid state. Consideration from this point of view of many solid reactions involving the use of ammonium chloride brings clearly to light the true character of these reactions. Thus, the use of ammonium chloride as a flux before soldering operations is based upon its ability to react with metallic oxides. Rose[4] has shown that many metallic oxides and compounds react quite readily with ammonium chloride at higher temperatures. Ammonium chloride has been used widely in the dehydration of hydrated chlorides at higher temperatures in order to repress hydrolysis and the consequent formation of basic salts. In the J. Lawrence Smith method[4] the addition of ammonium chloride aids in the opening up of silicate ores. In the electrolysis of fused chloride melts for the preparation of various metals, the occasional addition of ammonium chloride to remove the basic chlorides which form is recommended.

In further extension of our proposal we are summarizing briefly some of the experimental work carried out in this laboratory during the past few years involving the action of ammonium chloride at higher temperatures upon various metals, oxides and carbonates. All reactions are characteristic acid reactions and may be expressed by the following equations:

$$Fe + 2NH_4Cl = FeCl_2 + H_2 + 2NH_3$$
$$CdO + 2NH_4Cl = CdCl_2 + H_2O + 2NH_3$$
$$MgCO_3 + 2NH_4Cl = MgCl_2 + 2NH_3 + H_2O + CO_2$$

Experimental.—Rare earth oxides, Fe_2O_3, MgO, PbO, PbO_2, CdO, MnO_2, Sb_2O_3 react completely with ammonium chloride at 250° to yield the corresponding chlorides. The oxides of calcium and barium react more slowly. NiO, CuO and V_2O_5 give products of indefinite composition. Zinc oxide reacts to give a mixture which, after the removal of the excess ammonium chloride, yields a product that may be distilled unchanged at a red heat and is presumably the compound, $ZnCl_2NH_3$. Oxides of uranium are converted into uranyl chloride. ZrO_2, Al_2O_3 and BeO appear to react but slightly.

Carbonates such as $CaCO_3$, $MgCO_3$, $MnCO_3$ and $ZnCO_3$, were also found to react completely with ammonium chloride under the same conditions. The ammonium carbonate which is formed is dissociated and removed at the temperature of the reaction.

Reactions of this type have been utilized for the preparation of pure anhydrous rare earth chlorides.[6] The oxides are heated with an excess of ammonium chloride until complete reaction takes place. The mixture of rare earth chloride and excess of ammonium chloride is then placed in an all glass vacuum furnace and heated to remove the latter by sublimation at temperatures between 300-320°. In a similar manner anhydrous magnesium chloride and manganous chloride were prepared in better than 98 per cent purity. It should be noted that in the case of maganous chloride, a high purity material could be obtained only if the manganese dioxide was pure. Commercial MnO_2, Mn_2O_3 or Mn_3O_4 reacted only partially.

In contact with air and at temperatures between 200-300° C. ammonium chloride rapidly corrodes most of the common metals such as iron, nickel, copper, tin, magnesium and alloys such as brass, bronze, Monel metal, Inconel, Hastelloy A, C and D, and high and low carbon steels. In a vacuum, nickel seems to stand up best. It is significant in this connection that ammonium chloride vapor is more active than dry hydrogen chloride.[6]

In the reaction of ammonium chloride with various oxides it has been noted that such volatile chlorides as ferric chloride are removed along with the excess ammonium chloride during the process of vacuum sublimation. This suggests the possible utilization of these reactions in the removal of objectionable impurities from such materials as sand, zirconia, and clays.

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PAPERS IN ECONOMICS

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The five papers on the program of the Economics Section concerned the general topic, "Population Trends in Illinois and their Relation to Economic Problems of the State."

Presentation of the papers was followed by a discussion of the effect of population trends in Illinois upon rural schools, the rural community, the medium sized city, and the large urban center of Chicago, upon employment opportunity and the need for providing for workers displaced in agriculture and mining.

No chairman was elected for the following year.

(Signed) W. H. VOSKUIL, *Chairman*

Population Trends in Illinois and Their Relation to Economic Problems of the State

Symposium

NOTE: The first paper in the symposium, "History of Population Growth in Illinois and a Forecast of the Future," by H. L. Kellogg, State Planning Engineer, Chicago, was presented at the Friday morning General Session, and is published in No. 1, Volume 28, of the Academy's *Transactions*.

Occupational Changes in the Gainfully Employed Population of Illinois From 1870 to 1930 With Economic Consequences

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In 1930 one-fourth of the gainful workers in Illinois were in the manufacturing and mechanical industries. Another 15 per cent were in trade and 22 per cent were almost equally divided between clerical and domestic and personal service. These four classifications totalled 62 per cent of all gainful workers. Agricultural pursuits claimed only 11.1 per cent. Of all those gainfully occupied (3,184,684) 72.8 per cent were native white, 21.2 foreign-born white, 5.5 per cent negro and 0.6 per cent other races. Of the negroes 42 per cent were in domestic and personal service and 31 per cent in the manufacturing and mechanical industries.

The statistics pretty clearly indicate the reasons why unemployment in Illinois is so widespread during depressed times. Since the manufacturing and mechanical industries in this state are largely dominated by those making durable goods, Illinois is, under normal conditions, more unfortunate than states whose gainful workers are more evenly distributed among all the occupations.

This situation is much more acute than it was in 1900. Thirty years ago the number of persons gainfully occupied (not necessarily employed) in durable goods manufacturing was around 185,000. Those gainfully occupied in the consumption goods field numbered about 256,000. Agriculture claimed a much larger number—462,000. In 1930 the gainfully occupied were: durable goods manufacturing, 700,000; consumption goods, 415,000; and agriculture, 354,000. Thus we see that the gainfully occupied in durable goods manufacturing have increased 278 per cent; those in consumption goods have increased 62 per cent, and those in agriculture have decreased 24 per cent.

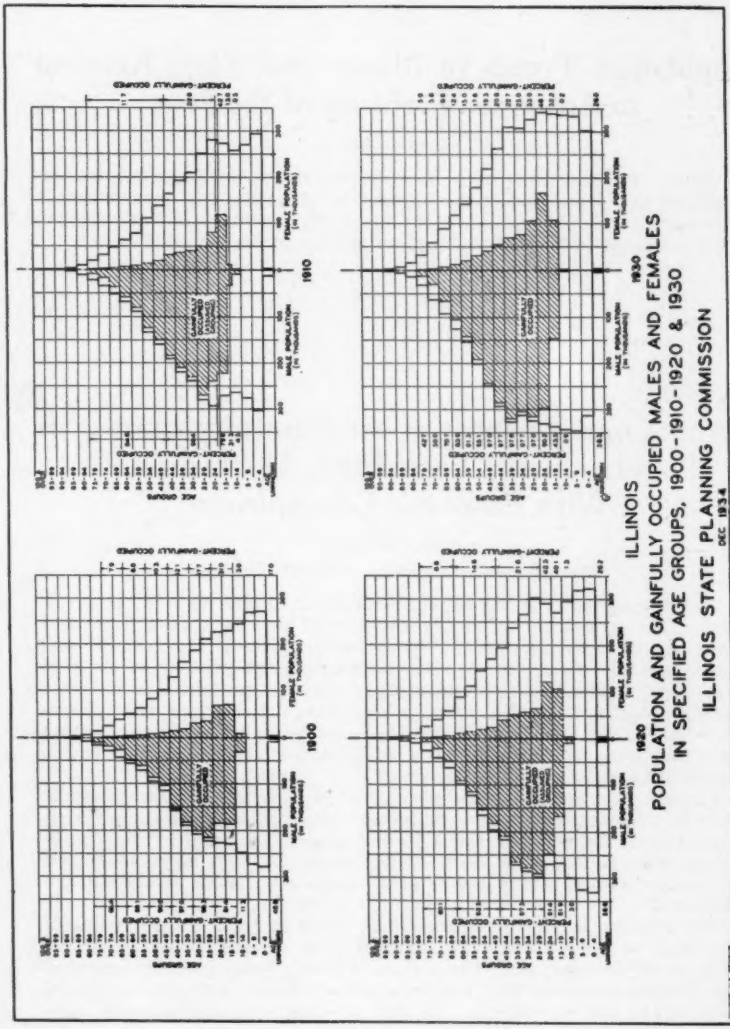
ILLINOIS
POPULATION AND GAINFULLY OCCUPIED MALES AND FEMALES
IN SPECIFIED AGE GROUPS, 1900-1910-1920 & 1930
ILLINOIS STATE PLANNING COMMISSION
DEC 1934
1910
1930
1900
1920

Fig. 1.

Two other important trends in employment are noted: (1) the unusual increase in those in the service industries as compared with production; and (2) the steady gain made in the number of women in the various occupational groups.

In 1870 almost 69 per cent of all persons gainfully occupied in Illinois were in the production industries, and 31 per cent were in the service industries. By 1930, of all persons occupied 45.50 per cent were in the production industries and 54.5 per cent in the service industries, an increase of 76 per cent in the case of the service industries and a decrease of 34 per cent in production. Despite this occupational shift the gain in numbers of those occupied in production increased in Illinois from 1870 to 1930 much more rapidly than in the United States, the respective percentages being 725 and 427. Another comparison along this line is illuminating: In 1870 Illinois contained 6 per cent of all persons in the service industries and in 1930, 7.5 per cent, although it contained (1930) only slightly more than 6 per cent of the total U. S. population. In 1870 more than half of all workers in Illinois were in agriculture; in 1930 only 11 per cent were.

In 1870 slightly more than 29 per cent of the total population was gainfully occupied; of males 10 years and over, 41 per cent were occupied; of females the same age, 7.3 per cent. Since 1870 the percentage of females occupied has been rapidly increasing until in 1930 almost 30 per cent were occupied. The proportion of occupied males 10 years and over had increased by 1930 to 76.8 per cent, yet had fallen back to that point after attaining 80 per cent in 1910. Undoubtedly the World War had something to do with that displacement of men by women.

This increase in women in the various occupational classes leads us to inquire further where the greatest occupational increases have been. The 1930 census shows us that of all women (10 years old and over) in Illinois gainfully occupied, 26.9 per cent were in domestic and personal service, 26.6 per cent in clerical occupations, 17.5 per cent in the manufacturing and mechanical industries, 13.5 per cent in the professional class, and 10.5 per cent in trade. What is more illuminating is the fact that in 1930 women constituted 58.4 per cent of all those gainfully occupied in domestic and personal service, 50.1 per cent of all those in clerical positions, 43.4 per cent of all the gainfully occupied in professional service, 16.1 per cent of all in trade, and even 12.1 per cent of all the gainfully occupied in the manufacturing and mechanical industries. Only 2.3 per cent of women are now reported as gainfully occupied in agriculture.

Viewing all of those in Illinois gainfully occupied from the economic point of view, we find that the numbers in the least secure occupations, the wage-earning class, have increased by more than 1,000,000 since 1900; while the middle class, composed of officials, those in trade, most of the professional class, those in public service who are not owners, and some of the personal service class, have increased by 175,000. This middle class now represents about 10 per cent of all those gainfully occupied. The owners of businesses, clergy, the top professional class and the farm owners and tenant farmers, all of whom have been in the past relatively secure economically, comprise almost another 10 per cent, though their numbers have increased only 35,000 in the past 30 years. Putting the farmer in the secure class under present economic conditions is a dangerous procedure, for about 10 per cent of farm families are now on relief. Further, the U. S. Department of Agriculture finds that the net cash income per farm *family* in the United States has decreased from $564 in 1929 to $116 in 1932. Should the farmers be removed from the secure class we are left with a group occupying but 3.2 per cent of all gainfully occupied persons in the state.

If we further examine the economic status of our wage earning classes we find that the average annual wages of full-time employees in the manufacturing industries in 1929 was $1,482 per individual worker; in the service industries (1933), $1,235; in retail distribution (1933) $1,010; and in wholesale trade (1933) $1,630. These figures do not represent a very large average income for any of the major classes of work.

Retail and wholesale sales, and service establishment receipts have fallen off almost 50 per cent from the 1929 level, making the return on capital invested in such enterprises so low that domestic and personal service workers have been thrown out of employment, adding greatly to the public relief load. In 1929 per capita retail sales for the state were $486, but in 1933 they were only $218.

In examining farm incomes, we find that in 1929 the average gross income per farm in seven southern counties was less than $1,000, and in 37 counties it was less than $2,000. For farmers' dwellings, in some 17 southern townships the average 1930 valuation of the farm houses is less than $250. In 25 southern counties the bulk of the townships show an average valuation per farm house of less than $1,000. Contrasted to these low valuations, a number of northern townships show an average for farm houses above $4,000.

Viewed also from the standpoint of relief, evidence that Illinois' problem is more acute than that of many other states is found in examining unemployment figures. In 1930 Illinois had 6.2 per cent of the total U. S. population, 6.5 per cent of all those gainfully occupied in the United States, but 8.9 per cent of all the unemployed were in Illinois. Sixty per cent of the unemployed were in the production industries and 30 per cent in service industries.

Twenty per cent of all those in Illinois listed as gainfully occupied in 1930 applied for jobs to the National Re-employment Service or to the Illinois Department of Labor Employment Service during the 10-month period ending in June, 1934.

In conclusion, attention should be called (1) to the large proportionate shift from employment in production industries to the various classes of service employment, (2) to the large proportionate decrease in agriculture, (3) the large proportionate increase in manufacturing and mechanical industries, and (4) the fact that the economic effect of these changes tend to some extent to offset each other in times of depression.

The Future Population in the Agricultural Industry in the State of Illinois

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The population living in unincorporated places and in the open country in Illinois declined steadily in the forty-year period, 1890 to 1930, from 1,630,960 to 1,343,659 people, a decline of 17.6 per cent. The number of people actually living on farms in Illinois in 1930 was 999,391.[1]

The decline of farm population in these 40 years was both in numbers of families on farms and in size of families, for there was a decrease of from 262,953 to 235,974 families on farms, or 10.3 per cent in this same forty-year period. The decrease in the number of families on farms was not a steady decrease, for there was an increase in the decade 1890 to 1900, and in the decade 1910 to 1920. There was an increase in families per farm, for the number of farms decreased about 20 per cent in 1910-30.[2]

The movement away from the farms in the forty-year period prior to 1930 in Illinois was occasioned by a number of factors, including expansion of agricultural opportunities in the western part of the United States, the attraction of opportunities in non-agricultural pursuits in urban centers, the excess of population in the country due to a higher birth rate than in the city, and in the last decade to advancing agricultural technique, a gradual decline in the per capita consumption of foodstuffs, the increased difficulty in maintaining our agricultural export trade, and the disparity of prices unfavorable to the farmer.

Under pre-depression conditions it might be expected that the numbers engaged in the agricultural industry would continue to decrease, for even now half the farms of America produce almost 80 per cent of the products "sold or traded," according to the census definition.

The recent depression has reversed the trend of the movement of population to and from farms. In 1930, the first year of the depression, migration to and from farms about balanced. By 1931 migration from farms in the United States had decreased to two-thirds of a million below the pre-depression level, while migration to farms continued at the old level. In 1932, there was a further drop of nearly half a million in the number of migrants from farms, while migration to farms diminished only slightly. During 1931 and 1932 the farm population increased 750,000 in the United States by migration from the cities, in addition to about 900,000 excess of births over deaths; but in 1933 migration from the farms increased slightly, while that to farms decreased greatly with a resultant net migration from the farms of about 225,000. For 1934, the two movements may again be almost balanced, despite drought and cotton and tobacco acreage reduction.[3]

In Illinois the migration to farms occurred in areas near urban and industrial centers, and in general, onto the poorer lands. For example, studies which have been conducted by the Agricultural Experiment Station of the University of Illinois indicate that there was very slight migration to farms

[1] Fifteenth Census of the United States: 1930, Composition and Characteristics of the Population of Illinois.
[2] Ibid: Population Bulletin on Families in Illinois.
[3] O. E. Baker and T. B. Manny, "Population Trends and the National Welfare," mimeographed publication of the Bureau of Agricultural Economics, United States Department of Agriculture, page 7.

in Champaign County from 1930 to 1935, whereas the open-country population in Alexander County, near Cairo, increased over 10 per cent in the same period. Moreover, early returns from the 1935 Agricultural Census show an increase in the number of farms in 58 of 61 counties on which data have been released.[4] The largest increase, 42 per cent, occurred in Alexander County where over half the population were on relief in July, 1934.

This movement back to farms in Illinois may be a temporary movement, and as soon as economic conditions improve in the urban centers there may again be a movement away from the farms, causing a still further decline in the farm population. In this connection, it was interesting to note that most of the migrants from the farms in the United States in 1934 were apparently people who had sought safety with rural relatives or friends during the depression, and who were now able to resume their work in the cities or to obtain aid from the civil work officials, or the relief agencies. Relatively few, apparently, were young people going to the cities for the first time.[5]

Present indications are that Illinois may, however, have more people on the land in the next ten years than in the past ten years. The cities are interested in moving their unemployed onto the land, in order to reduce the relief burden in the cities. There is an effort to move families off so-called sub-marginal land, which is being purchased for forest and pasture uses by governmental and other agencies. Many young people who normally leave the farm are remaining because of a lack of opportunity for employment elsewhere. It is difficult to predict how many will thus be added to the farm population in Illinois in the next five or ten years, but with improving economic conditions in non-agricultural pursuits, it would be surprising if there were more than a ten per cent increase in the next decade.

Urban centers have not had a sufficient natural increase in population to maintain themselves.[6] In every state of the United States without exception the ratio of children under five years of age to women 15 to 45 years of age (child bearing age) was lower in the urban than in the rural population according to the Census of 1930. The number of children under five years of age in all cities of the United States over 100,000 population lacked 20 per cent of being sufficient to maintain the population of those cities. There was a deficit of from six to eight per cent in towns of 2,500 to 100,000 population. Villages and suburbs, on the other hand, have a surplus of 30 per cent. The farm population had a surplus of 50 per cent. From one-half to five-eights of our natural increase is now found in the farm population, although this group constitutes about one-fourth of the total population of the United States.[7] It is to be expected, therefore, that with the return to normal industrial conditions, the net migration will be again toward the cities.

If there is to be an increase in the number of people on farms in the State of Illinois over the next quarter of a century, this increase probably will not be in the number of commercial farmers, but rather in the number of those who operate so-called family-size farms, part-time farms, or subsistence farms. It is expected that the largest increase will come in part-time farms, and the smallest in farms furnishing a subsistence living. The extent of the movement of urban families to rural areas will depend to a large degree on the amount and rate of decentralization of industry which will minimize the problem of transportation.[8]

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[4] Press Releases on the Preliminary Agricultural Census Reports, Bureau of Census, United States Department of Commerce.

[5] O. E. Baker and T. B. Manny, op. cit., page 7.

[6] Ibid, page 10.

[7] Warren S. Thompson, "Movements of Population," American Journal of Sociology, Volume XL, Number 6, May, 1935, page 719.

[8] Cf., F. L. Morrison and J. H. Sitterly, "Rural Homes and Their Non-Agricultural Workers," Bulletin 547, Ohio Experiment Station, Wooster, Ohio, February, 1935, page 34.

Population Problems in Illinois Mining Communities

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The two unusual characteristics of the mineral industries that distinguish them from the others are (1) The exhaustibility of mineral deposits, and (2) the irregular geographical distribution of deposits of the various minerals. The consequence of these two characteristics of mineral deposits is that mining communities are frequently isolated and far removed from market centers, and that the productivity of a mining district registers a small beginning, a gradual rise to maximum output, followed by decline and eventual extinction. In Illinois, where coal mining is carried to a greater or lesser degree in nearly half of the counties of the state, examples of each of these stages in the history of a mining district may be found. Some of these coal mining districts are located in or near agricultural districts and urban communities and the unemployment resulting from fluctuations in the mining industry may be absorbed by economic activity in other fields. Such for example, is likely to be the case in such important coal mining counties as Peoria, Sangamon, Madison, and St. Clair. On the other hand, coal producing counties in southern Illinois are more or less isolated, the dominant activity is coal production, and the economic welfare of the local population, both miners and tradesmen, is primarily dependent upon the activity of the mines. A serious problem of unemployment, therefore can arise, apart from any major cyclical movements of general industrial activity, due to changing conditions within the mining industry itself. The purpose of this brief paper is to analyze some of the changes that have occurred in the mining districts of southern Illinois, and to consider the problems arising out of these changes.

Before considering the trend of employment in the coal industry of the southern fields, it may be of interest to point out some of the general characteristics of the coal industry in Illinois since 1905. In figure 1 are shown the curves of production, number of men employed, number of days worked, and output per man per day.

The decline in output of coal, due to competitive fuels, and the decline in employment opportunity due both to falling demand for coal and increasing effectiveness of production has affected the southern Illinois mining district as well as the other coal districts in the state.

Particular attention should be directed to the declining portion of the employment curve in its bearing on employment opportunity. This becomes especially significant when an analysis is made of the occupational distribution of gainfully employed and the geographical distribution of population in these southern counties.

Suggested means for redirecting unemployed into productive work include the following:

(a) Moving the men out of the community (not feasible as a mass movement).
(b) Broadening the industrial base of the community, i. e., a diversification of industry.
(c) The possibilities offered by reforestation.
(d) Possible industries based upon forest resources.
(e) Industries based upon local resources other than forests.
(f) Public works.
(g) A rehabilitation of coal mining.
(h) Subsistence homesteads.

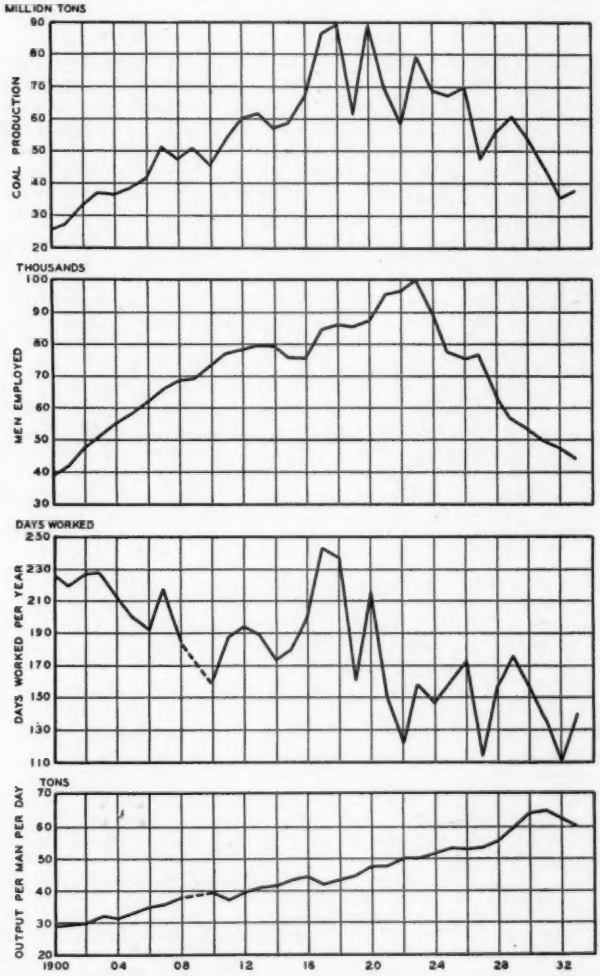

Fig. 1.—Coal produced, number of men employed, days worked per year, and output per man per day, 1900-1933.

Industrial Opportunities in Illinois for the Absorption of a Growing Wage-Earning Population*

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In spite of a decline in the rate of population growth in the United States, each year adds more persons to our wage-earning class. Fifty per cent of the increase comes from farms. Agriculture in Illinois, which is a wealthy agricultural state, has developed to a point where increased productivity per acre makes present acreage and man power adequate to supply present and near-future needs, so that the farms cannot absorb their surplus population. This group, then, must seek work in the non-agricultural industries—production, manufacturing, and marketing.

The industrial opportunities that Illinois can offer to the on-coming wage earners are based upon certain natural advantages. Illinois occupies a keystone position as an industrial state in the Upper Mississippi Valley with its large consuming market, adequate transportation facilities, available power, and abundance of diverse mineral materials. The Great Lakes, the now completed Illinois Waterway, and the usual railway transportation facilities combine to make this state the focal area for the assembly of raw materials and the distribution of manufactured goods into the surrounding states.

Illinois' raw materials include coal and oil, which form the basis of an energy-using civilization, and the state supplies a large part of the energy needs of seven states. Illinois has the largest coal reserves east of the Mississippi River, and although the industry has suffered from the invasion of fuel oil, natural gas, and Appalachian coals into the Illinois coal market area, coal will nevertheless continue to form the basic energy-fuel for domestic and industrial use. Improvements in the preparation of coal, more equitable competition, the restoration of industrial production, and the adaptation of coal to uses now served by oil and gas, will be reflected in a larger and more prosperous coal industry for the southern Illinois counties.

Chicago is a strategic center for the steel industry, using ore from the Minnesota mines and cheap Lake-cargo coke from the Appalachians. This enables the Chicago district to deliver the steel ingots or semi-finished steel shapes to the fabricators of steel goods in competition with steel from other districts. Eastern Wisconsin and northern Illinois and Indiana furnish a large market for steel goods. Another large market exists in the southwestern states. The transportation of steel goods down the Ohio River from the Pennsylvania and Ohio mills, finally to penetrate this vast market by rail, has increased yearly. The opening of the Illinois Waterway will doubtless be to the advantage of the steel mills in the Chicago district in transporting their product to St. Louis, which is Chicago's distributing center for the southwest territory. There are fewer locks to negotiate on the Illinois Waterway as compared with the Ohio River, and the lower production costs in Chicago further favor Chicago in capturing this market.

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The non-metallic materials offer another important field of opportunity, particularly the structural clay products industries. This is peculiarly a local industry because of the wide distribution of suitable raw materials and because of the local market for this type of product. Obsolescence of homes, needed repairs, increasing demands of the home-owner for better ventilation, improved insulation against heat and cold, better protection against fire and vermin, and in general a demand for more comfortable and complete living quarters at lower cost, is confronting this industry. Research is continually working towards satisfying these requirements. The present tendency of urban population to move to suburban areas and the perceptible trend toward decentralization by industries from the congested urban centers into smaller communities is further creating new demands from the building industry. The construction industry is certain to advance with the restoration of industrial activity in general. The necessary resources are abundant and readily available in Illinois, including clay, limestone, sand and gravel, building lime, and glass sand.

Illinois possesses almost unlimited supplies of excellent glass sand, among the purest sand deposits in the world. These deposits along the Illinois River valley are favorably located, with reference to markets, fuel, and transportation, for the manufacture of glass products. Although this state ranks first in output of glass sand, it is fifth in the manufacture of glass products. A substantial quantity of the sand is exported to eastern states for manufacture of glass products which in turn are imported. However, the location of industrial enterprises is constantly changing in favor of more economical relations between raw materials and markets. The enlargement of glass making facilities in the midst of large glass markets of the Upper Mississippi Valley will ultimately be brought about.

Research is continually revealing new uses for our natural wealth. New demands are created, and Illinois' geographic position, mineral wealth, and populous market will enable her to increasingly open up industrial opportunities in the manufacture of products based on mineral utilization.

PAPERS IN GEOGRAPHY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Geography Section consisted of eleven papers, all of which are here represented except the following:

"Land Utilization and Crop Production of Illinois by Counties," by Emerson Hall, Southern Illinois State Teachers College, Carbondale.

"Coal in Illinois," by Harry L. Adams, Bloomington High School, Bloomington.

"Land Utilization in the Town of Portland, Maine," by Mabel P. Crompton.

The present chairman was re-elected to serve for the year 1935-36.

(Signed) FLEMIN W. COX, *Chairman*

Palestine in Transformation

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University of Illinois, Urbana, Illinois

The Palestine of Yesterday.—Southwestern Asia is usually credited with having been the cradle of the human race. Likewise it was for centuries a great transit land across which goods and peoples moved between Europe and the Far East. Curiously enough, in spite of the advantages of an early start and the stimulus of commercial intercourse, Palestine and its neighbors have been rated among the most backward of civilized countries.

The responsibility for this retardation lies in the human rather than the environmental factor. For the past 400 years the country has been under the iron heel of the Turk—a fact of profound significance. Centuries of misrule and oppression have borne their natural fruit and in 1918 little Palestine was a country impoverished and almost depopulated.

The Palestine of Today.—Yet in the past 15 years the Holy Land has been witnessing a remarkable transformation. The ousting of the Turk and the substitution of British authority set the stage. The influx of Jewish immigrants with their initiative, enterprize, and capital has provided the action, and a colorful drama is being enacted. It is a case of "new wine in old bottles," and a land historically "old" is today economically "new," with the stimulant reaching almost every one of the country's activities.

Since the British have taken over the mandate, the population of the country has more than doubled. A single city, Tel-Aviv, whose site in 1909 was marked by a row of sand dunes, has today a population of over 70,000, making it rank second only to Jerusalem.

Agriculture, the mainstay of the country, has taken on a new lease of life. Present accomplishments include the reclamation of thousands of acres of sandy waste and malarial swamp. The orange acreage has been expanded until it now covers an area eight times that of eleven years ago. Jaffa, the chief port, recorded an export in 1912 of 1.8 million cases of the fruit; in 1934 this had grown to 5.5 million cases; and oranges now constitute about 80 per cent of the value of all Palestine exports.

Industry has likewise made notable advances. Under the old regime, soap from olive oil and wine from local grapes were the only manufactures of any size and these were operated with crude apparatus and primitive methods yielding a product of low grade. It is estimated that at present there are almost 4,000 industrial plants, employing some 20,000 workers and representing an investment of over $20,000,000. About ⅔ of these plants are still operated by manual labor, but mechanical energy now being made available is changing this condition materially.

Two industrial projects are of more than passing interest and deserve special mention. They are located in the Jordan-Dead Sea depression at the eastern edge of Palestine.

The Jordan River has a total fall of about 3,000 feet and hydroelectric plants are being constructed to utilize the power of the river and its tributaries. One unit is complete and others are being constructed, the total capacity to be some 100,000 h. p. Galilee and an artificial lake will provide

storage so essential in a region of long summer drought. In a land without coal, cheap electric energy will be all important in providing light and power over the country.

At the southern, or Dead Sea, end of the same valley another unique industry is getting under way. The Sea is some 1,300 feet below sea level, is without an outlet, and has an average annual temperature of about 100°F. Thus the Sea is a gigantic natural evaporating pan. Insolation here is 2.5 times as effective as on the Mediterranean and the waters carry 25 per cent salts instead of the 3-4 per cent of ordinary sea water. Tests show that 125 gallons of water may be evaporated daily by the sunshine, from every square foot of surface.

Among the salts present are two of special importance—potassium and bromine. The maximum concentration of these was found at a place 175 feet below the surface and a 30 inch intake pipe was laid to this point. The brine is pumped into great shallow concrete basins and the valuable salts recovered by differential dessication. The plant is partially completed and some salts have been exported. At full capacity it is expected to yield some 70,000 tons of potash annually. One of the problems confronting the enterprize is transportation of the product to the rail head at Jerusalem 25 miles away. The Sea is 4,300 feet below the Hebron ridge 10 miles away. Trucks, now used, will be eventually supplanted by a railroad extension.

Improvements in transportation have kept pace with other activities. Sixty years ago Palestine had no wheeled traffic and no surfaced roads. In 1913 there was one automobile; in 1932 there were 3,000 and most of the main roads had been macadamized. Some 600 miles of government railroad, much of which was a legacy of the World War, is now supplemented by both motor and air transport.

For Haifa, at the foot of Mount Carmel, there has just been completed the best harbor in the eastern Mediterranean, and for the first time shipping may load and unload at the docks instead of by lightering. Haifa is also one of the termini of the famous oil pipe line carrying crude oil from Iraq to tankers here and at Tripoli. Plans contemplate the erection of storage tanks and refineries at Haifa.

Of fundamental importance to all progress is the education of the native population. The most serious problem in Palestine today is the Arab-Jew question and education should serve to make cooperation between the two easier.

In 1927 there were over 750 schools providing a general education maintained by the government and various religious organizations.

All in all, the changes in both material and intellectual conditions is little short of phenomenal. Everywhere from Dan to Beersheba, construction, planting, and manufacturing are proceeding at a swift pace. Palestine has changed more in the past 15 years than it has in the preceding 15 centuries.

Surface Temperatures of the Gulf Stream and the Waters on Its Margins

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Oceanographers agree that the term Gulf Stream should be restricted to that portion of the great North Atlantic current system which flows from the edge of the Pourtales Plateau (south of Cape Hatteras) to the Tail of the Grand Banks (Fig. 1). The name Florida Current is reserved for that portion of the system which issues through the Straits of Florida and continues to the edge of the Pourtales Plateau. This discussion is limited to the western half of the Gulf Stream as defined above.

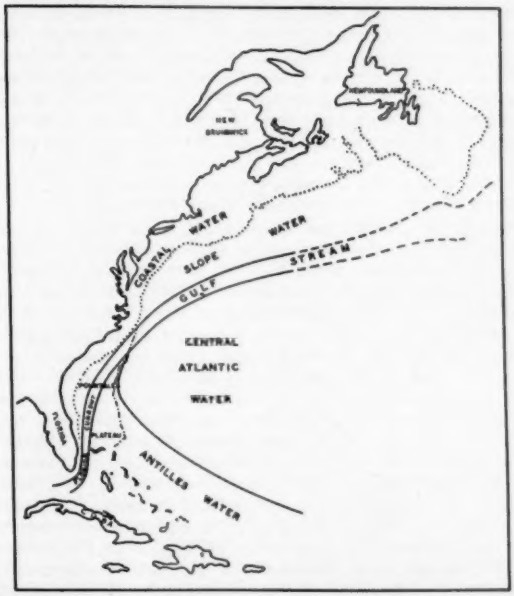

Fig. 1.—The location, width, and relative position of the coastal water, slope water, Gulf Stream, Florida Current, central Atlantic water, and Antilles water. The dotted line is the 100-fathom curve. The dot-dash line indicates the seaward limit of Pourtales Plateau.

About eight years ago a thermograph for automatically recording sea-surface temperatures was installed on the commercial vessel *Coamo*, which plies between New York and Puerto Rico. Since that time the Weather Bureau, steamship companies, the Canadian Meteorological Service, and the American Meteorological Society have cooperated in installing additional thermographs on commercial vessels which sail on regular schedules over various routes on the western North Atlantic. The thermograms, which are

all sent to the Marine Division of the United States Weather Bureau, form the basis of the discussion. At present more than 1,000 records have been sent in and many of them have been reduced from a temperature-time graph to a temperature-position chart. About 100 such charts have been constructed, which show the temperature pattern over a wide area within any particular week. From these charts various definite areas are distinguished by to their surface-temperature characteristics.

Seaward from the 100-fathom curve is an area which varies in width with the temporary migrations of the Gulf Stream. From no width at Cape Hatteras this deep water area increases to a maximum of about 180 miles to the south of Narragansett Bay. Owing to its great depth, 1,000 to 3,000 fathoms, it has a smaller annual temperature range than the coastal water to the north and west. Data from the New York-Bermuda route show the minimum to be about 42°F. which occurs the last week of March, and the maximum to be about 75°F. which occurs early in September. This annual range of 33 degrees is only slightly less than the 35 to 39 degree range for the shallow coastal water.

In the winter and early spring months the temperature of the water at any latitude and longitude close to the average position of the Gulf Stream is apt to change within a few days as much as the annual range for the year. Such an event is occasioned by offshoots of warm surface water from the Gulf Stream invading the area generally occupied by this slope-water. These invasions are but short-lived at best. Preliminary investigations do not seem to bear out the thought that they might be wind driven.

Between the slope-water and the Gulf Stream is a narrow band which, owing to its contrast in temperature to that of the Gulf Stream, is popularly called the "cold-wall". Its average width is approximately 21 miles and it has an average change of temperature of one degree per mile.

The Gulf Stream is that narrow band of warm water that flows on the outside rim of the Central Atlantic area, or Sargasso Sea. Off Cape Hatteras the stream is only 50 miles wide, between New York and Bermuda 60 miles wide, and south of Halifax 70 miles wide. By the time it reaches the Tail of the Grand Banks it has probably widened to about 100 miles though there is no definite information at this point. The Gulf Stream is distinctly set off from water on either side by sharp temperature contrasts.

The annual range of temperature is smallest off Cape Hatteras being about 11 degrees normally (from 74°F. to 85°F.). The minimum comes in March and the maximum in September. In its movement to the northeast the stream cools and the annual range increases slightly. South of Halifax the lowest is about 69°F. and the warmest about 82°F., a range of 13 degrees. The surface temperatures of the Gulf Stream do not vary more than 2 degrees from their normal and a variation of as much as 2 degrees is most likely in the winter., The period of record has still been too short to determine whether there will be a cyclical variation from the normal.

Warm offshoots of Gulf Stream water invade the slope-water area and cause a temporary migration of the main body of Gulf Stream water. There is no indication of any definite seasonal migration of its course.

South and southeast of the Gulf Stream lies the broad expanse of Central Atlantic water. West of the longitude of Bermuda, its most striking characteristic is the homogeneity of surface temperatures. It has a mean annual range of about 17 degrees in the northern part. The southern limit of this body has been tentatively set at the place where there is an annual range of about 11 degrees. Here there is a small but distinct break in the temperature consistent throughout the year though varying in latitude from winter to summer. This break in temperature probably coincides with the northern edge of the North Equatorial Current and Antilles Water.

A Field Study of Bloomington-Normal[1]

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INTRODUCTION

The Bloomington-Normal urban area[2] includes 6.95 square miles and is occupied by approximately 37,000 people. These people in their utilization of this area, have unconsciously divided it into six land utilization patterns which include several types of distribution from the one extreme of an even scattering over the area to the other extreme of a concentrated arrangement of forms within the landscape. It is the ultimate purpose of this survey to study this variety of land uses and the various types of patterns found within the Bloomington-Normal urban area.

This report is a summary of a survey made during the first week of January, 1935, of the land utilization in the Bloomington-Normal urban area. No attempt has been made to cover the complete geography of the area.

PROBLEM

The area dealt with in this report is called the Bloomington-Normal urban area. The first problem becomes that of defining this area. The incorporated area of Normal directly adjoins the northern limits of the incorporated area of Bloomington, thus making a contiguous political area. In some cases, however, the corporation boundaries are unsuitable for the urban area boundary. Some of the town of Normal in the western and the eastern portions is omitted because the areas are not built up for urban uses but are small tracts of land used for farming, gardens, or pastures. It is also necessary to omit a small portion of the northwest and northeast sections of Bloomington for the same reasons. In the case of Bloomington, however, it is necessary to include additional areas outside of the city limits along a few streets which are built up for urban uses. The Bloomington-Normal urban area is therefore a distinct, irregular area with boundaries directly established according to the urban uses and occupance of the land, and is determined through actual field observations.

The second problem consists of the recognition of the types of land uses within the urban area. The site of the Bloomington-Normal urban area includes the junction of railway routes and highway routes, and embraces land near the headwaters of the Sugar Creek drainage system which flows southward toward Illinois River. Within this urban area there are distinct patterns of land occupance or use which together make up the complete and unified pattern of land utilization within the Bloomington-Normal urban

[1] The writer wishes to acknowledge the valuable assistance of those persons who furnished information for this survey. Special thanks is given to "The Daily Pantagraph" of Bloomington who furnished the air photos.

[2] Bloomington-Normal is located in Central Illinois on the Alton Railroad 15 miles north of the midpoint between Chicago and St. Louis.

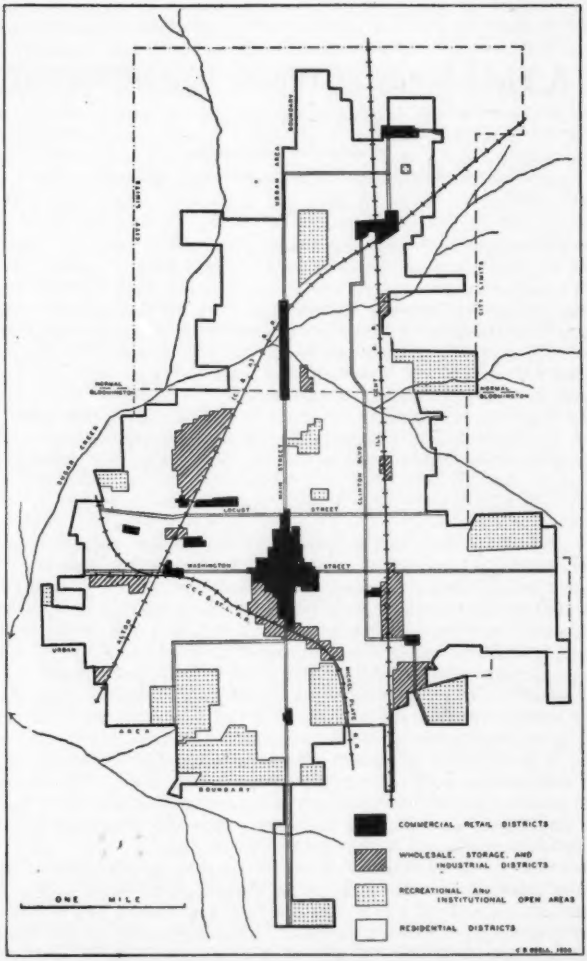

Fig. 1. Map showing land utilization in the Bloomington-Normal urban area. A composite of six maps each showing a single type of land use. Wholesale, storage, and industrial areas are here combined because they overlap. Open air recreational and institutional areas are likewise combined; indoor units of these two uses are located throughout the patterns of commercial retail and residential uses, and occupy areas too small to be shown on this scale map. Residential districts are not here subdivided as described in the text.

area. These distributions include the following types of units found in the landscape:

(1) The transportational units include railroads as external units, and street cars, busses, etc., as internal units.
(2) The production units include factories, industrial plants, etc.
(3) The commercial units are divided into wholesale, retail, and storage groups.
(4) The residential units are divided according to poor, medium, and superior groups.
(5) The recreational units include parks, playgrounds, etc.
(6) The institutional units include government, with city hall, jail, etc.; religion, with churches; education, with schools; and others, including charitable homes, hospitals, cemeteries, etc.

DISTRIBUTION OF THE SIX TYPES OF LAND USES

The distribution of these units was first recognized by six individual maps, each showing the distribution of one group of units as listed above. These six maps were then combined to make the composite map of the entire urban area (Fig. 1). The patterns or distributions were analyzed through the aid of photographs. An analysis included the relationships of the patterns, one to another, and the mutual relationships of the cultural items to the natural within these patterns of land occupance units. Thus the complete report classified and presented the distribution of items in many subpatterns of land occupance units within the Bloomington-Normal urban area. This brief summary will attempt to present only a few of the findings and conclusions resulting from the field survey and subsequent report.

Transportational units.—The distribution of transportational units is characterized by alignments which divide the urban area into numerous districts of irregular shapes and sizes. Some of the larger areas, particularly those set up by the railroad pattern, including the large triangular one, can be taken as areas in the study of other land use patterns. The large area used by the Alton Railroad Shops (Fig. 2) separates residential districts. Other transportational patterns act as webs connecting and holding the other types of land use distributions together in the complete land utilization pattern of the area. For example, the street car and bus lines are connecting links between retail and residential sections.

The complete transportational pattern is divided into an external pattern including units operating beyond the limits of the urban area, and the internal pattern including units operating entirely within the urban area. The external transportational pattern includes the railways, highways, both state and federal, and airways. The internal transportational pattern includes streets and alleys, street cars and busses, and other public utilities, including the distribution of water mains, sewer and gas mains, telephone, and telegraph. These lines of transportation and communication occupy rectangular patterns and in many cases are coincident with one another. All of these items occupy relatively small percentages of the total urban area, but are of extreme importance in the complete land utilization pattern by setting up districts within the urban area.

Production units.—The production units include one per cent of the total area (according to planimeter measurements on the original maps). The factories are concentrated in two alignments with a few outlying units located upon sites of particular interest to them. Use is made of the wide right-of-way along the Illinois Central as well as land along the Big Four and Nickle Plate roads. As far as areal coverage is concerned this pattern is of the least importance but becomes of value through its distinct relationship with the railroad pattern.

Fig. 2. Air photo of the Chicago and Alton Railroad shops in the northwest part of Bloomington. This view also shows portions of the residential sections.

Fig. 3. The central portion of the Bloomington-Normal urban area from an elevation of 4,000 feet. The central business district, a part of the transportation pattern, and portions of the residential districts are shown. The light patch of the central business district is shown by an absence of trees and corresponds in shape to the central black area on the map (Fig. 1).

Commercial units.—The distribution of the commercial units of the Bloomington-Normal urban area is concentrated for the most part in the southern half within the triangle set up by the railroad pattern (Fig. 3). The commercial establishments of the urban area may be divided into three groups according to type, namely, retail, wholesale, and storage. Three distinct sub-patterns can thus be recognized, and the location of each in conjunction with the other patterns of land use can be shown.

The retail pattern is divided into three separate district groups, namely, central business district, outlying business districts, and outlying business units not included in the other two types of units. The first, central business district, is an example of a concentration of interests into a compact area; the second, the outlying districts, of a decentralization of interests from the central business area to various communities; and the third, individual units, of the dispersion of individual units into individual neighborhoods.

In spite of the small proportion of the total area included within the central business district, there are a large number of total retail establishments of the city compactly arranged within the area. Of 502 retail stores in Bloomington as listed by the United States Census for 1930, there are 229 located in first floor units on Washington, Jefferson, Main, and Center streets within the central business district.[3] These streets are on the four sides of the Court House square. In addition to the retail stores on these streets there are 53 personal service establishments. On Main street alone there are 155 establishments and 15 vacancies in first floor units.

The utilization of the square for upper floor units is important. The concentration decreases with distance from the square with the long axis coinciding with Main Street. In general, the elevations of the buildings increase nearer the square, a fact which further emphasizes the concentration and overlapping of activities within the central business district. The profile of the buildings seems to correspond with the profile of the hill upon which the original town was laid out. The foresight of the early settlers in choosing a high, well drained site, yet level enough for building purposes, is thus recognized.

The wholesale and storage sections of the urban pattern are concentrated into alignments within the southern portion and coincide somewhat with the transportational pattern. In general, the commercial pattern (particularly the central business district) is the focusing point of the entire urban area.

Residential units.—One of the most important patterns of land use within this urban area is the one of habitation or residential units. Residential units occupy three-fourths of the total urban area. The lower grade sections comprising about a third of the total urban area are closely related to the railroad pattern and are mainly in the western portions. The medium sections make up about two-fifths of the total urban area and include districts in the central and east portions. The superior sections, including about one-twelfth of the total area, are located in the east and a few scattered sections in the central parts. The extremes in quality of residences, from the lowest to the highest grade is great. About 58 per cent of the houses are home owned with 90 per cent of the total units being single family dwellings.

Recreational units.—The two groups in the recreational pattern, outdoor and indoor, present examples of the two extremes in types of distribution. The outdoor pattern is one utilizing land on the periphery of the urban area,

[3] Profiles of these streets were made with the classification of the United States Census for retail establishments with an additional item of personal services for banks, professional offices, etc.
Since this survey was made there have been a few changes in number of establishments but not enough to alter the large percentage within the district.

where land is more available and less likely to be occupied in other urban uses. The indoor pattern is for the most part concentrated within the central business district and illustrates the extreme of compactness in the distribution of units. The areal expanse of the recreational pattern is not large as compared with the other urban patterns in amount of built up land, but is of importance in its tendencies to prevent expansion of sections of the other patterns by being of enough importance to many persons so that plans to encroach upon it with other land uses are at present prohibited.

Institutional units.—The institutional pattern is of minor importance in proportion to the total area involved, but is of much importance in linking up other patterns of land use within the urban area. Concentration of units within or near the edge of the central business district further emphasizes the importance of the central position of the urban area. Small scattered units intermingled within the other patterns is characteristic of the institutional pattern.

CONCLUSIONS

(1) The use of land within the Bloomington-Normal urban area is primarily related to the railroad pattern which is, in turn, closely related to the topographic pattern.

(2) The original town of Bloomington which occupied a relatively high site between two branches of Sugar Creek has become the central business district of the present urban area. The profile or skyline of the buildings closely corresponds to the profile of the hill.

(3) The residential pattern which occupies 78½ per cent of the total urban area is divided into sections by railroad and topographic patterns.

(4) The distribution of commercial units is directly related to the compact distribution and the quality of the residential units.

(5) The percentages of the total Bloomington-Normal urban area included within each pattern of land use units are given in the following list:

		Per cent[4]
Transportational Units		4.2
Production Units		1.0
Commercial Units		6.3
Central business district	1.7	
Outlying business districts	1.3	
Wholesale districts	1.5	
Storage districts	1.8	
Habitation Units		78.5
Poor sections	31.0	
Medium sections	40.0	
Superior sections	7.5	
Recreational Units		7.0
Institutional Units		3.0
Total		100.0

From this list it is found that the three closely related transportational, commercial, and residential patterns cover 89 per cent of the Bloomington-Normal urban area. These important patterns are directly related to the rolling topography of the natural environment by varying degrees of compactness and groupings of quality.

[4] Percentages calculated from planimeter measurements on the six original land use maps.

A Guatemalan Banana Farm

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ABSTRACT

This paper is a report of field work in the eastern lowlands of Guatemala. The subject is an establishment known as Maya Farm, a basic functional unit in a district of banana production, not "Mayan" except by virtue of proximity to the Mayan ruins of Quiriguá.

The farm occupies a section of the floodplain on the north side of the river between the stream bank and the mountain foothills. The area is about four square miles. A third of this is virgin forest, a dense stand of tall trees and vines, broad leaved evergreens flourishing in a perpetual abundance of heat and moisture, not jungle in the sense of tangled thicket but high woods in which the ground is fairly dark and free of undergrowth. Most of the trees are fast growing weeds of no value for lumber. The forest is at the north end of the farm, away from the river, where the floodplain land is low, heavy and swampy, and adjacent hill land is leached and infertile.

The rest of the farm has been cleared for bananas. The process is one of felling the forest and leaving the wood to rot on the ground while the banana plants are growing up. Of land once planted to bananas a large proportion has been abandoned, having proved unprofitable for production and now being reoccupied by forest. In general the productive lands are on the natural levees, and the abandoned lands are at a greater distance from the river, where drainage is poor, near the still swampier lands left in virgin forest.

After reduction of the plantation area to about 800 acres there has been some increase to a total of about 1,000 acres, made possible by construction of a carefully planned system of drainage. Since the farm is practically all floodplain, occasional flooding is to be expected in almost every part of it.

The annual output of the farm is nearly 300,000 stems of fruit for the American market. This is equivalent to a capacity of nearly 400,000 stems for the English market, the difference being due to the picking of less mature and therefore more quickly produced fruit for the more distant market.

This output involves a capacity for cutting and transporting 6,000 stems of American fruit in one day. The fruit matures at a rate which allows for cutting a week's quota at one time, and after cutting immediate shipment is required. Therefore harvesting and shipping on one day a week is expedient. Organization of the farm is based on this fact.

Prompt shipment is made possible by a mule tram system reaching every part of the plantations and coming to a focus at a railway siding whence passing trains carry the product on scheduled time to a ship in port.

In charge of the farm is an American overseer, living with his family a life that is rather isolated but otherwise pleasant and comfortable. The overseer's house is an attractive modern bungalow surrounded by well landscaped grounds.

The laborers are Guatemalans and other Central Americans of Indian and mestizo blood and Jamaicans of negro blood. They work under a foreman who has risen from the ranks. Their quarters are in a separate grassy clearing and consist of a row of well built barrack-like "camps," simple but adequate, providing a one-room dwelling for each laborer and his family.

There are no other forms of occupance on the farm. The laborers' camps and supervisor's house front on the railway, which is the only highway, and which serves as a line of attachment in the occupance of the whole floodplain. As already indicated, Maya Farm is part of a much larger enterprise. A tract of a thousand acres has been found large enough for one unit of production under an overseer. Accordingly some twenty-four farms of approximately this size have been established along the railway, for the development of nearly all available banana lands of the Motagua floodplain, to form the Guatemalan Division of the United Fruit Company.

Nearly all of the older lands have become unproductive, on account of soil depletion in general and the Panama disease in particular, a persistent blight destroying the crop. It is not yet known whether the banana can ever become a permanent occupant of fertile land or whether a suitable product can be found to succeed it on worn out land—a product which, like the banana, is perishable and yet portable, attractive and unique.

London and Paris: A Comparison of Their Locations

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Early sites of the two cities.—There is a marked resemblance between the original locations of London and Paris. London grew up on a hill in the marshes bordering the Thames, while the earliest site of Paris was the island of Lutetia in the Seine. Each was situated at the lowest point at which the river could be bridged. London had one advantage—the Thames is tidal 20 miles above London Bridge. Paris, on the other hand, is below tidal limit.

Surroundings of the two cities.—The cities are each in the center of a shallow basin or syncline which formed economically self sufficient regions in the Middle Ages. The London and Paris Basins differ in shape, but structurally are much alike, both being composed of a series of cuesta and intervening clay vales. There are minor differences—one being that while clays predominate in the innermost layer of the London Basin, there are more limestones in the Tertiary rocks around Paris, and again there are sections of the London Basin covered with glacial till whereas there was no glaciation in the Paris Basin.

Tertiary Rocks.—Travelling east from Paris or west from London to the outer edge of the basins, the Tertiary beds are crossed, which have always been rich wheatlands. Near the center of each basin there were clay deposits which gave rise to brick and tile, and porcelain industries. In addition Paris had limestone for building material, while early London relied more on brick for this purpose. The limey soils on the eastward facing edge or scarp of the Tertiary rocks in the Paris Basin are covered with vineyards.

Cretaceous Rocks.—In both basins Cretaceous rocks, chalk and clay, extend under and beyond the Tertiary beds. In the London Basin the chalk forms the Chiltern Hills to the north and the Downs to the south. The pasture on this porous limey soil is excellent sheep pasture. Beyond the chalk the gault clay extends in a wide belt, of which the Oxford Clay vale forms a part. Here is some of the richest land in England. Sugar beet and fruit crops have led to the development of the jam industry, and beef and dairy cattle are raised.

Beyond the vineyards of the Tertiary escarpment of the Paris Basin the chalk country of Champaign is reached. The soil here is more suitable for sheep grazing than for crops. This is Champaign *Pouilleuse*, meaning dry, dusty or poor country, but owing to use of fertilizers most of it has been improved, and in some of the deep valleys vineyards cover the lower slopes. The chalk ends in a steep brink, at the base of which the clay crops out in a belt corresponding to the Oxford Clay in England. This is Champaign *Humide*, or moist Champaign, and when drained it forms excellent agricultural land. At the base of the chalk escarpment where the soils are a mixture of chalk and clay are the vineyards from which the famous Champaign wines have been produced for centuries.

The Rocks beyond the Cretaceous Beds.—The cuesta formation is continued around the London and Paris Basins in oölitic (Bedford) limestone scarps, famous for sheep grazing, good building stone and iron ore, while beyond it lies another clay region which when well drained is used for vineyards and crops. Space does not permit a description of the grassy scarps and wooded vales between the Cretaceous rocks and the ancient massifs, but they have also contributed largely to the wealth which has made London and Paris what they are.

Conclusions.—After comparing the location of these two cities and noting points of resemblance in their hinterlands it seems inevitable that the development of London and Paris should be somewhat similar. The structural variations are reflected in the great variety of natural resources, agricultural and otherwise, which led to the self sufficiency of the London and Paris Basins. As the natural wealth of the two regions was developed and the natural routes which converged on the two cities were followed by roads, London and Paris became market centers, and later, manufacturing towns.

In the Middle Ages, as the surplus of the products of their surroundings increased, London and Paris rose to importance as great seaports. In modern times, however, it would seem that the similarity in their development is at an end. Paris remains the chief market and manufacturing center of Northern France, but as a port she is superceded by her outports of Rouen and Le Havre. London, too, is still a market and manufacturing center, but she has also held her own as a seaport, and is the chief entrepôt of the world (largely because she is the market for the British Empire). Owing to the increase in the size of ocean vessels, however, modern port development tends to gravitate down the Thames estuary, and the largest ocean liners dock at Southampton, which for passenger traffic, at least, may now be looked upon as the outport of London.

Industrial Survey of LaSalle-Peru-Oglesby

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ABSTRACT

Landscapes of the LaSalle-Peru-Oglesby area are dotted with industrial smokestacks. Although located in the very heart of the Corn Belt, this tri-city area is notably industrial. What kind of industries are here? Why are these particular industries here? These are the questions which come immediately to the mind of the geographer who visits LaSalle-Peru-Oglesby.

The major industries of the area are closely related to the mineral resources here, and may be classified as falling into three groups (1) cement, (2) metal and metal products, (3) chemical. The development of these industries is due chiefly to the presence of rich deposits of two basic minerals, coal and limestone. Three local bituminous coal mines are the principal sources of fuel in all of the industries, and local *LaSalle* limestone is the chief raw material used in the cement mills.

The industries most closely related to the natural resources of the area are those engaged in the manufacture of Portland cement. There are three of these, having a combined total capacity output of approximately 22,200 barrels of cement daily, or, 8,103,000 barrels annually. The Marquette mill alone, which is one of the largest single cement units in the world, has a storage capacity of 1,500,000 barrels. All three mills obtain their principal raw material from their *LaSalle* limestone deposits, and the clays and shales juxtaposed with them. These deposits are near the surface, being quarried in two of the mills and both mined and quarried in the other. The estimated supply is enough to last from one to two hundred years at the present rate of extraction. Gypsum is brought from Ft. Dodge, Iowa. Coal is obtained principally from local mines, although some is shipped from Wilmington and southern Illinois.

Ten of the leading fourteen industries of this area are engaged in producing metal and metal products. These plants may be grouped as (1) those either producing zinc or using zinc as a principal raw material, and (2) those producing other metal products. In the first group there are seven which are concerned with zinc. Two of these are zinc mills in which zinc ore and zinc concentrates are smelted, zinc is rolled for commercial use, and sulphuric acid is made as a by-product. The first of these was established here in 1857 by Frederick Matthiessen and Edward Hegeler, two graduates of the School of Mines in Freiburg, Saxony. The location at LaSalle was selected because the coal supply here is the best within convenient transportation distance from Mineral Point, Wisconsin, the source of the first zinc ore to be used. The Illinois Zinc mill was located in Peru for the same reason. There are only two other zinc plants in Illinois, and Illinois is second only to the state of Pennsylvania. Hence, LaSalle and Peru are notable as producers of zinc.

Three of the zinc-using plants are those which make pre-finished metals for fabrication in metal products, to eliminate plating after the article is

shaped. All three use zinc smelted in the local mills as one of the basic raw materials, and each plant is unique in the type of metals produced.

Zinc weatherstrips and zinc-coated shingle nails are the chief products of two other industrial plants of this area which draw upon the local zinc mills for their supply of basic raw material.

The Western Clock Company, the largest producer of alarm clocks in the world, is located in Peru. This plant at present employs 2,300 persons, makes many thousands of clocks and watches daily, and pays out more than two million dollars annually in salaries. Raw materials used come from all over the world, and Westclox timepieces are marketed in every civilized country in the world. Local mines usually provide the coal used.

Parts for agricultural machinery are made in two other industrial plants of this area. The chief products of these plants are wheels of all sorts, tractor attachments, and grey iron castings. Local coal serves as fuel, and the Corn Belt is the area served.

A chemical plant which is the sole American producer of potassium permanganate as well as a producer of other valuable chemicals is located near the zinc mills. Coal from the zinc company's mine and sulphuric acid from the zinc concentration process are used in the chemical plant.

Corn Yield and Climate in Illinois*

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In eight sample counties in Illinois the correlation of variations in corn yield with fluctuations in climatic factors reveals striking differences within the state, a condition not revealed when the state is studied as a unit. In numerous instances the correlation coefficients differ so much and so gradually that the difference is probably not due to sampling or to accident. For example, Wallace[1] found an insignificant coefficient of +.22 between May mean temperature and corn yield in Illinois. However, when sample counties are studied, the dividing line between the negative coefficients (to the north) and positive coefficients (to the south) corresponds roughly with the May mean temperature isotherm of 61° F.

The lateness of spring frost, measured by the number of days between the last killing frost in spring and June 1, gave significant negative coefficients in the west central part of the state. In the computation of partial correlations this same factor came out even more significantly negative in the same area.

Phases of June temperature included mean temperature, accumulated degrees above 90° F., number of days 90° F. or higher, accumulated degrees below 60° F., number of nights 60° F. or lower. The mean and low temperature phases gave significant negative correlation with yields in the northern part of the state, while high phases of June temperature are negatively significant in the south.

Significant negative correlations with high phases of July temperature are found as far north as McLean County, but in the north part of the state significant correlations were not discovered for any phase of July temperature.

Both mean and high phases of August temperature give significant negative correlation with corn yield in the south and central parts of the Illinois Corn Belt. The north part of the state shows significant negative correlations with low temperature phases and significant positive coefficients with mean temperatures.

The coefficients for May precipitation, some above ±.30, are all negative for the north part of the state and positive for the south part, although none are significant. Thus we can easily understand how the state as a whole gave +.09 for this factor.[2] For June rainfall the three most southerly counties gave significant positive coefficients, while Kane, Bureau, and McLean counties gave negative coefficients.

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[1] Wallace, H. A.: "Mathematical Inquiry into the Effect of Weather on Corn Yield in the Eight Corn Belt States," *Monthly Weather Review*, XLVIII, No. 8 (Aug., 1920), 439-446.

* NOTE: The eight samples from Illinois (Bureau, Coles, Kane, Macoupin, McDonough, McLean, St. Clair, and Stephenson counties) were included as part of a larger study of fifty-five counties within and just beyond the margins of the Corn Belt of the United States. Thirty-five climatic factors were investigated. The period of years, in all cases ending in 1932, for Illinois was 22 years for eleven of the factors and 19 years for the other twenty-four.

[2] Wallace, Op. cit.

Both weighted and unweighted July rainfall were investigated. In general, the southern two-thirds of the Illinois Corn Belt gave coefficients of positive significance, while the northern samples were either positive or negative and without significance.

In Illinois no sample counties gave a simple correlation coefficient as high as ±.40 for August precipitation. (In this study coefficients as high as or higher than ±.40 were considered significant.)

Conclusions.—Variations in the average per acre yield of corn in the eight Illinois counties studied as samples seem to be correlated significantly with several climatic factors rather than with one single critical factor. Temperature factors correlate more significantly as a group than do precipitation factors. In addition, variations in temperature extremes, measured in accumulated degrees above 90° F. and below 60° F., seem to be more significant than mean temperatures.

In a more comprehensive study the Corn Belt of the United States was divided into four major forecast areas on the basis of the correlations between corn yields and climatic factors. Three of the four areas are represented in Illinois.

Of the two southwestern sample counties (St. Clair and Macoupin), and Coles County to a lesser degree, it may be said that mid-season temperatures are very important and that early-season temperatures and mid-season precipitation are somewhat less important. Thus a later-than-average spring, with May and June having cooler temperatures and greater precipitation than is normal, is mildly indicative of a higher than average corn yield. If July has more than average precipitation and both July and August are cooler than normal, a higher than average corn yield is strongly indicated.

Thus it would seem that the southern boundary of the Corn Belt in Illinois, commonly explained by soils and topography, may depend just as much on the fact that temperatures, especially mid-season temperatures, to the southward are increasingly unfavorable to corn yield.

Of the two northern sample counties (Stephenson and Kane) it may be said that they are representative of a more extensive area along the northern margin of the Corn Belt, in which early-season temperature factors seem to be critical. This area seems normally to lack sufficient heat during the period preceding reproduction, while more than normal precipitation during the same period seems disadvantageous. Variations in mid-season temperatures and precipitation, except night temperatures lower than average during August, seem to have little relation to the yield per acre in this area.

The three central counties (Bureau, McDonough, and McLean) belong to what may be referred to as the central core of the Corn Belt. Although in these counties corn yields are nearly a hundred per cent greater in some years than in others, such fluctuations seldom correlate significantly with fluctuations in any of the thirty-five climatic factors investigated. The explanation is not at all clear. It is perhaps because of a blending of the factors important on the north with those significant on the south, with the result that fluctuations in any single factor are of minor importance as an influence in reducing or increasing corn yields in this central core area. Of the thirty-five factors investigated, not one gave a coefficient as high as ±.40 for Bureau County.

The areal divisions herein mentioned have no regard for state boundaries. It would seem, then, that their discovery is dependent upon the use of areas smaller than states.

The relatively low multiple correlation coefficients obtained for Kane, McLean, and Macoupin counties suggest that it is not yet possible to forecast the yield of corn in Illinois several months in advance with the same degree of certainty with which it can be done for some other areas of the Corn Belt of the United States.

A Gazetteer of the Origin of Illinois Nomenclature

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A Gazetteer of the Origin of Illinois Nomenclature is a compilation of the origins of the names of the counties and principal cities, rivers, and lakes of Illinois. This has previously been done for several states of the Union, but never, so far as the author is aware, for this state. The origins of these names were summarized under two classifications: (1) geographic or non-geographic and (2) linguistic.

From these two summaries we find that the origins of only 24 per cent of the Illinois names can be traced to geographic features. Of the remaining 76 per cent, about ⅔ (50 per cent of the whole) are named after men (prominent citizens, early settlers, founders, war heroes, governmental officials, etc.), and 19 per cent after other places, most of which are in eastern United States.

If a detailed summary of each division is made we find an interesting correlation. The county names are predominantly (80 per cent) named after men, mostly war heroes and governmental officials. The origins of the city nomenclature is fairly evenly divided. Those that are named after men are largely named for founders, early settlers, or prominent citizens. About 90 per cent are named after men, places, or geographic features, and these three origins stand in the ratio 7:5:4. About 4/5 of the rivers and lakes are named after geographic features. This variation can probably be explained by the fact that the rivers and lakes were largely named by the Indians, who, as was their custom, gave names taken largely from their surroundings; while in contrast, the cities and counties were usually named by the founders or early settlers, in some cases long after the Indian had been removed. They named their new home after a former home or after some prominent citizen or official. For this reason, in the second classification we find that the state, river, and lake nomenclature is primarily of an Indian origin, whereas the names of the counties and cities are predominantly of an English origin.

SUMMARY

	Counties	Cities	Rivers and lakes	Total
Named after a geographic feature	12	43	18	73
Non-geographic feature	90	147	5	242
Named after men	80	74	1	155
Named after places	8	52	2	62
Unclassified	2	21	2	25
English	89	138	8	235
Indian	7	22	12	41
French	5	13	2	20
Spanish		2	1	3
Classical		3		3
Biblical		4		4
All others	1	8		9

If anyone is interested further in this work, a copy is available at the Urbana division of the Illinois Historical Survey and at the University library.

PAPERS IN GEOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

All seventeen papers on the program of the Geology Section were read at the meeting, and all but three are here represented. Those omitted are:

"The Bearing of Field Relations in the Illinois Coal Field on the Time of Coalification," by Harold R. Wanless, State Geological Survey and University of Illinois.

"Some Evidences of the Shrinkage of Certain Illinois Coal Beds Since Their Burial," by Gilbert H. Cady, State Geological Survey.

"Taxonomy of Certain Mississippian Productidae," by A. H. Sutton, University of Illinois.

Average attendance at the meeting was forty, maximum was forty-five.

Dr. Harold R. Wanless, Department of Geology, University of Illinois, was elected chairman of the section for 1935-36.

(Signed) D. JEROME FISHER, *Chairman*

Some Recent Attempts to Correlate the Later Paleozoic of America and Europe

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Illinois State Geological Survey, Urbana

In a paper presented before the Illinois Academy of Science in 1929, the author presented a correlation of the Illinois coal seams with European horizons. Coal seam No. 2, whose flora is best known, was correlated with the floras of the coal seams in Ibbenbüren and Piesberg in the Ruhr district. There is an exhaustive monograph of the flora of Ibbenbüren by Hans Bode published in 1927 by the Prussian Geological Survey. Furthermore, an extensive correspondence between Dr. W. Gothan of the Prussian Survey and Dr. Hans Bode and myself, and the exchange of many specimens made it apparently certain that the correlation was correct. Since the coal seams of Ibbenbüren and Piesberg belong to the upper part of the Westphalian group C, it seemed evident that the Pottsville would fill the remaining portion of group C, probably the entire B and A of the Westphalian, and perhaps reach into the Namurian. On the other hand, our entire McLeansboro and the Carbondale above coal No. 2 would necessarily fall into the Stephanian of the European classification. This is further borne out by the similarity of the floras in coal No. 5 and No. 6 with the Stephanian floras of Western Europe. More weight is added to this argument by the coal ball floras of Illinois from coal seams No. 5 and No. 6 which are distinctly Stephanian in character.

Two European visitors to the International Geological Congress of 1933 attempted correlations which were published in the autumn of 1934. Paul Bertrand of Lille in France accepts for his correlations the statements of the late David White and of the writer, admitting that we both have collected for many years in our respective territories and taking for granted that our determinations are correct. Dr. Jongmans had a different attitude. He made an extensive collection in the field covering West Virginia, Pennsylvania, Illinois, and Kansas, during his stay in this country, which extended from the middle of July to the end of September, 1933. He came to the conclusion that there is no Stephanian to be found in the United States, and that part of the Pottsville, the entire Alleghany, Conemaugh, and Monongahela, and part of the Dunkard, correspond to the Westphalian C. He correlates Westphalian A, B, and part of C, with the Pottsville, while Bertrand believes that the uppermost Namurian also corresponds to the American Pottsville.

As may be seen on the chart, my Carbondale corresponds somewhat to the Westphalian D of Bertrand. I have made no attempt to fix definitely the lower boundary of the Pottsville, since the investigation of the Pottsville has been in the hands of the late David White, whose authority in these matters was unquestionable. I sincerely hope that when White's great work about the Pottsville of Illinois is published by Dr. Charles Read, he will make a special effort to determine the lower boundary of the Illinois Pottsville in its relation to the Westphalian and Namurian of Western Europe.

While Paul Bertrand accepted my own determinations as made in my publications and in the collections which he inspected, Dr. Jongmans disagrees in many points of determination. For instance, he does not accept our *Pecopteris miltoni* which is actually the most common fern of coal No. 2, and which is also one of the most common ferns in the corresponding coal formations of Western Europe. He and Gothan, whose collaboration was published in the Yearbook of the Geologic Bureau of the Netherlands for 1933, based their conclusion on the comparatively small collection of material

WESTERN EUROPE		PENNSYLVANIA (J.&G.)	WEST VIRGINIA (J.&G.)	ILLINOIS (J.&G.)	UNITED STATES (P. BERTRAND)	ILLINOIS (A.C. NOÉ)
STEPHANIAN		—	—	—	MONONGAHELA CONEMAUGH	MC LEANSBORO
WESTPHALIAN	(D)	DUNKARD (IN PART) MONONGAHELA CONEMAUGH ALLEGHENY (POTTSVILLE)	DUNKARD (IN PART) (MONONGAHELA) (CONEMAUGH) ALLEGHENY	MONONGAHELA CONEMAUGH ALLEGHENY	ALLEGHENY IN WESTPHALIAN(D)	CARBONDALE
	C				UPPER POTTSVILLE	POTTSVILLE
	B	POTTSVILLE	KANAWHA GROUP	POTTSVILLE (MILL CREEK) (CROFTON, KY)		
	A		NEW RIVER GROUP	POTTSVILLE BATTERY ROCK	LOWER POTTSVILLE	
NAMURIAN	C	?	UPPER POCAHONTAS	PROBABLY ABSENT	?	?
	B	?		NOT INVESTIGATED BY JONGMANS		?
	A	MAUCH CHUNK POCONO (IN PART)	LOWER POCAHONTAS			

Fig. 1.—Chart showing correlation of Pennsylvanian strata in western Europe and United States.

which Jongmans brought home from his trip. In some cases he and I mean the same thing, but give it different names, and I hope by correspondence to be able to coordinate our determinations and nomenclature. He is quite right when he says, in his joint article with Gothan, that American and European paleobotanists should cooperate rather than work entirely independently.

Spores Characteristic of Illinois Coal No. 6*

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A large variety of fossil plant spores, many of them distinct from described forms, have been obtained from macerated residues of coal No. 6 in Illinois. This report discusses only a few of them, chiefly those which have been reported by earlier investigators, and are now identified for the first time from this country.

Although it has long been known that spores occur in Paleozoic coals, and it has been suggested that they be employed in stratigraphic correlation, only recently has enough evidence been collected to test their usefulness. Zerndt,[1] Potonie[2] and their students and collaborators have shown that different types of spores in the Polish basin and the Ruhr, although not confined to single coal seams, have more or less restricted ranges and are characteristic of different parts of the stratigraphic succession.

The need for additional information for geologic use makes desirable a systematic classification of these spores, following the conventions of taxonomic usage. Many of the spore forms will probably never be identified in terms of species as they are conceived from studies based on other parts of the plant because, if Paleozoic plants resemble modern plants, the spores of closely related species are often indistinguishable. Hence it is recognized that a classification based on spore form is of limited value in approaching a natural system, and should be accorded consideration mostly from the standpoint of convenience. The varieties of spores are sufficiently distinct to constitute valuable indicators of vegetational change and it is in this sense that it is proposed to use them. At present it appears essential as a means to that end to apply a system of binomial designation which is consistant with that of general Paleobotanical practice.[3]

Genus TRILETES Reinsch, 1883

Division LAEVIGATI Bennie and Kidston, 1886

Triletes reinschi (Ibrahim)

Figs. 1 and 2

1886, *Triletes* I Bennie and Kidston, Proc. Roy. Phys. Soc. Edinburgh, Vol. IX, p. 107, Pl. III, Figs. 1a, b.

1930, Spore 1.9 mm. Zerndt, Ann. de la Soc. Geol. de Pologne, Tom VI, p. 308, 312, Pl. I, Fig. 5a, b, Pl. III, Fig. 5a, b.

1930, *Triletes* Typ I Kidston, Zerndt, Bull. Int. de l'acad. Polon. des Sci. et des Lettres, Ser. B, p. 43, Pl. 1, Fig. 1.

* This work has been supported jointly by the Illinois Geological Survey and the National Research Council, the author having worked under the direction of Dr. G. H. Cady while this information was accumulated.

[1] Zerndt, Jan, Les Megaspores du Bassin Houiller Polonais, l'ere partie. Academie Polonaise des Sciences et des Lettres, Comite des Publications Siliesiennes, Travaux Geologiques No. 1; 1-55, 1934.

[2] Potonie, R., F. Loose, und C. Wicher, Zur Mikrobotanik der Kohlen und ihrer Verwandten, Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine, Band 4; 1-212, 1934.

[3] R. Thiessen (U. S. Bur. Mines Bull. 117, p. 71, 1920) has objected to the naming of isolated spores, but his studies here and especially those of later date have been chiefly concerned with thin sections in which it is doubtful that spores can be consistently identified.

1931, Typ 10 Zerndt, Bull. Int. de l'Acad. Polon. des Sci. et des Lettres, Ser. A, p. 172.
1931, *Triletes* I Kidston, Stach und Zerndt, Glückauf, Jahrg. 67, p. 1122.
1932, *Triletes* Typ I Kidston, Maslankiewiczowa, Acta Societatis Bot. Polon., Vol. IX, p. 158.
1932, *Sporonites reinschi* Ibrahim, Neues Jahrbuch f. Min. Geol. u. Paläont., Beilage Bd. 67, Abt. B, p. 449, Pl. XVII, Fig. 28.
1933, *Laevigati-sporites reinschi* Ibrahim, Dissertation T. H. Berlin.
1934, *Sporites primus* Kidston, Wicher, Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine, Band 4, p. 169.

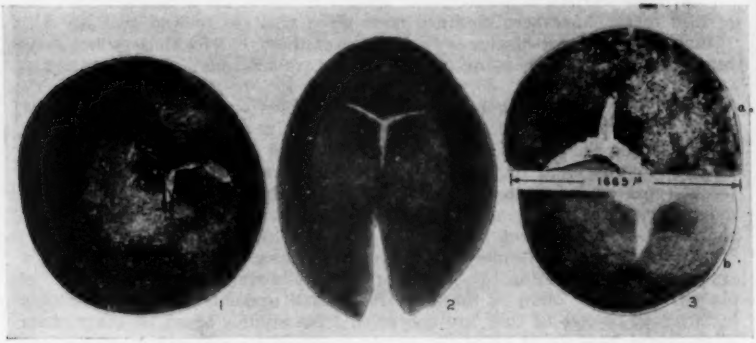

Fig. 1. *Triletes reinschi* (Ibrahim), 1800 microns diameter. Spore nearly opaque, photo by reflected light.
Fig. 2. *Triletes reinschi* (Ibrahim), oval specimen with distal side removed, photo by transmitted light showing the arcuate ridges and pyramic apex darker, due to local exine thickening.
Fig. 3. *Triletes* sp. (Type 14, form 1 of Zerndt) half of an individual. *a*, reflected light, *b*, (slightly smaller magnification) transmitted light.

This spore, reported from Scotland, Poland, and the Ruhr of Germany, appears to be the most widely distributed of the forms now well known. The nomenclature, however, has become somewhat confused so that a brief explanation seems necessary.

The rules of scientific biological nomenclature require that the first name, properly established for any organism, be applied thereafter in accordance with the law of priority, notwithstanding any seeming inconsistency due to inappropriateness or sentiment. In order to establish a new species, however, a latinized name must be applied. Numerical designations cannot be accepted.

Triletes I Bennie and Kidston, 1886, therefore does not constitute a valid species name and the first latinized name subsequently applied should be given recognition. The name "*Sporites primus* Kidston, 1886", recently given by Wicher is also in error. In the first place the name is new, Kidston never having used it in that form in the literature; hence the new name is attributable to Wicher, 1934, and to no one else. Secondly, since Wicher considers *Sporonites reinschi* Ibrahim, 1932, synonymous with Bennie and Kidston's *Triletes* I, it is evident that this was the first correct species name proposed for it.

The diameter of moderately large specimens of *Triletes reinschi* is nearly 2 mm. The surface has a smooth to granulose texture, and due to

preservation, is generally slightly undulatory. The pyramic areas are well defined; taken together they occupy about one-half the proximal side of the spore. (Kidston, 1886, states "two-thirds", but a planimetric measurement of his original illustration gives a value of about 47 per cent.) The exine is quite thick. This is the most common megaspore found in coal No. 6.

Triletes cf. *giganteus* Zerndt, 1930

1930, *Triletes giganteus* Zerndt, Bull. Int. de l'Acad. Polonaise des Sci. et des Lettres, Ser. B, p. 71-79, Pls. 9-11.

1931, Typ 1 Zerndt, Bull. Int. de l'Acad. Polonaise des Sci. et des Lettres, Ser. A, p. 170.

1934, *Triletes giganteus* Zerndt, Acad. Polon, des Sci. et des Lettres; Travaux Geol. No. 1, p. 13-15, Pls. 1-5. Text fig. 2.

1934, *Sporites giganteus* Zerndt, Wicher, Arbeiten aus dem Institut für Paläobotanik und Petrographie der Brennsteine, Band 4, p. 172, Pl. 8, fig. 9.

1935, *Triletes* cf. *giganteus* Zerndt; Schopf, Trans. Ill. Acad. Sci. Vol. 28, p. 106, Pl. 1, fig. 5.

This species is the largest yet recorded for any type of spore. Zerndt mentions a specimen 6.4 mm. long and Wicher reports a large spore encountered in the Ruhr coals attaining a length of 7.5 mm. An individual, probably identical with this species, from Illinois coal No. 6 at Johnson City has a length of 7.8 mm., folds transverse to the long axis, and a small portion of the apex missing. It is probable therefore that these are not extreme measurements and in life the spores may have been even larger. It is not surprising that such bodies were mistaken by earlier workers for sporangia rather than individual spores. Other smaller specimens, one of which is figured, are discussed in the author's previous paper cited above. These must be considered as closely related to Zerndt's species since the wall texture, size, and morphology are in general agreement. *T.* cf. *giganteus* is not as abundant in Illinois coals thus far studied as it apparently is in many Polish coals.

Division Apiculati B. and K. 1886

Triletes sp.

Fig. 3a, b

This characteristic Illinois form is assigned to the division Apiculati although the spines are very short and rarely, obscure. It is found abundantly with *T. reinschi* just above the blue band in the No. 6 bed at Belleville, Illinois. The figured specimen is smaller, and the pyramic areas which ordinarily occupy about half the proximal side, are for this reason proportionately larger than the average. The lips are characteristically spread apart leaving a wide trilete aperture. The texture of the lip is somewhat distinctive in that it forms a margin for the aperture which is narrow, glossy, rounded and somewhat articulated. This spore is quite similar to a specimen figured by Zerndt[4] in 1932 which would now be included in his Type 14, form 1.[5]

Division Zonales B. and K. 1886

Triletes triangulatus Zerndt, 1930

1930, Spora 0.5 mm. Zerndt, Ann. de la Soc. Geol. de Pologne, Tom VI, p. 306, 312, Pl. I, fig. 1a, c, Pl. III, fig. 1a, b.

[4] Zerndt, J. Megasporen aus dem Zwickauer aun Lugau-Ölsnitzer Karbon. Jahrbuch für das Berg—und Hüttenwesen in Sachsen, Jahrg. 1932; Pl. 3, fig. 15.
[5] Zerndt, J. Op. cit. 1934; p. 18.

1930, *Triletes triangulatus* I Zerndt, Bull. Int. de l'Acad. Polon. des Sci. et des Lettres, Ser. B, p. 51, Pl. 7, figs. 19-24.

1931, Typ. 17 Zerndt, Bull. Int. de l'Acad. Polon. des Sci. et des Lettres, Ser. A, p. 178.

1932, *Sporonites regalis* Ibrahim, Neues Jahrbuch f. Min. Geol. u. Paläont. Beilage Bd. 67, Abt. B, p. 449, Pl. XVI, fig. 24.

1934, *Triletes triangulatus* Zerndt, Acad. Polon. des Sci. et des Lettres Travaux Geol. No. 1, p. 19, Pl. 18, fig. 1-24.

1934, *Sporites triangulatus* Zerndt, Wicher, Arbeiten aus dem Inst. für Paläobotanik und Petrographie der Brennsteine, Band 4, p. 175.

1935, *Triletes triangulatus* Zerndt, Schopf, Trans. Ill. Acad. Sci. Vol. 28, p. 107, Pl. 1, fig. 6a, b.

This form is discussed elsewhere in this volume (Schopf, Op. cit.) and requires no further mention at this time. It seems to be limited to short zones of frequency, sometimes recurring several times in the height of a single coal bed.

Genus Lagenicula B. and K. 1886

At least two species occurring commonly in Illinois No. 6 coal are referrable to the genus *Lagenicula* as interpreted by Zerndt. One of these may be identical with *Lagenicula* Typ. 30 of Zerndt. The other and more common form is about equal in size (nearly 1 mm. long) and has a characteristic translucent exine. Descriptions will be published later.

Genus Monoletes (Ibrahim, 1933)

Monoletes ovatus Schopf, 1935

1935, *Monoletes ovatus* Schopf, Trans. Ill. Acad. Sci. 28, p. 108, Pl. 1, fig. 7.

This spore is small in comparison with the large macrospores previously discussed. Since spores of similar type have been found in the "pollen" chambers of large pteridospermic seeds, it may have functioned as a microspore, although some individuals of this type are quite large (approaching 700 microns). There is no evidence that a pollen tube was produced, so that it can be considered as a probable *microspore* which functioned most likely, under very specialized conditions. It may be permissable to call such spores "prepollen" as Renault[6] does, however it is doubtful that any features are present which would clearly distinguish prepollen morphologically from monolete microspores or isospores. It is still more doubtful that such prepollen is the phylogenetic forerunner of true pollen such as possessed by Angiosperms. There is some similarity between it and cycad pollen.

The predominance of *Monoletes ovatus* at two localities examined, and its presence at others, suggests that the plant which produced it must in some instances have contributed largely to the mass of the coal.

From the preliminary studies made thus far, the different spore species appear to be quite definitely limited to distinct zones of abundance within the coal bed. This zonal distribution will be of importance by its application to the theory of coal accumulation and in bed correlation.

The writer wishes to express his gratitude to Dr. J. Marvin Weller and to Dr. G. H. Cady for suggestions and assistance in the preparation of this paper.

[6] Renault, B., Bassin Houiller et Permien d'Autun et Epinac, Paris 1896, p. 270.

Results Obtained by Chromic-Sulphuric Acid Etching of Illinois Coals*

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The present paper gives some of the results of the use of the etching method in studying a complete column of Herrin (No. 6) coal collected at Nashville, Washington County, Illinois.

Seyler's method[1] was used in this study, with some slight modifications. Blocks of coal cut across the bedding were first polished. These blocks are as large as can be conveniently handled under the microscope, since large surfaces are desirable in order to follow changes in structure. This surface was ground with progressively finer grades of carborundum, then on a Belgian hone, after which it was polished with No. 2 and No. 3 alumina on billiard cloth. By reflected light the polished surfaces reveal no internal structure in the banded ingredients. The etching liquid consists of 10 cc. of strong sulfuric acid added to 30 cc. of a saturated solution of chromic acid with enough water to make complete solution possible. The solution is boiled until the chromic acid begins to precipitate. The block of coal is then placed in the solution, which is kept at the boiling point during the time of the etching, 45 seconds for Illinois coal. The blocks are taken from the etching solution, cooled, washed with water, dried, and gently rubbed with the repolishing cloth. The sections are examined with reflected light using an Ultropak objective.

The technique is relatively simple and the etched surfaces offer several advantages over thin sections. Etched surfaces frequently reveal structures not revealed in thin sections, in spite of the greater general usefulness of the latter for petrographic studies. The etching is selective in its action on the coal constituents. The resins, spores, cuticles, and fusain are not attacked, vitrain is next most resistant, certain parts of the clarain are least resistant. Some of the broad vitrain bands lose their brilliant color and become grayish black in color, but vitrain that is comprised largely of resin-filled cells retains its luster and the minute details of cell structure; even the pitting, middle lamellae, and original shape of the lumens are revealed, making possible the identification of the tissues in some instances. This woody lustrous variety of vitrain often grades into the gray, apparently structureless variety. These differences have not been observed in thin section. Often the broad bands of vitrain show no trace of structure under very high magnification. This variety of vitrain may be due to the complete disintegration of the cell structure. Xylem cells (Fig. 1, *a*) of the conducting tissue, parenchyma cells of the pith, and crushed steles (Fig. 1, *b*) are some of the structures found in the vitrain.

In one preserved fragment (Fig. 1, *c*) the lumens of the cells are filled with kaolinite, and the middle lamellae, the thickened lignified portion of the woody part, and the pitting in the cell walls are well preserved. Resins (Fig. 1, *d*) stand out conspicuously in the vitrain. Sectioning in two planes

* Published by permission of the Chief, Illinois State Geological Survey.

[1] Seyler, Fuel, vol. 4, No. 2, Feb., 1925.

shows the elliptical bodies to be resin rodlets, 3 to 4 mm. long. Some of the resins appear to have a darker ring around the outer margin, and this may be explained as the result of oxidation of the resin rodlet. Distinctly different globular bodies with a marginal ring and perforate openings in the center have been identified by some investigators as sclerotia (fungal bodies).

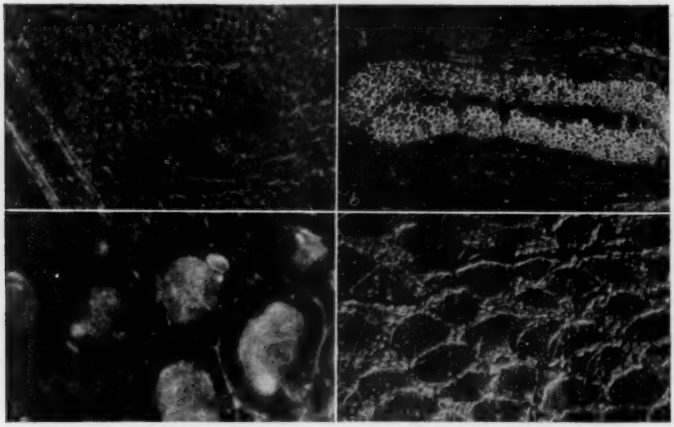

Fig. 1.—(a) Xylem cells of the conducting tissue (× 86); (b) crushed steles (× 25); (c) lumens filled with kaolinite (× 285); (d) resins preserved in vitrain (× 367).

In the clarain, the resins, spores, and cuticles are well preserved in a groundmass of heterogeneous detrital material. The resins occur singly and in groups, resin rods predominating over small lenticular bodies. The spores often show a black central portion which may be the gametophyte carbonized. The cuticles show the serrate edges of cell impressions. Certain tissues of cortical origin appear to be present as the suberized part of the periderm.

Fusian is preserved in lenticular fragments often showing well preserved cell structures, such as tracheids or a group of steles or a polystelic fragment. Resins occur in fusain in partings in the coal. These resins show peculiar concentric markings and some have mineral matter in the center of the rods.

Geologic Dating of Time of Coalification

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Statement of problem.—Did a given coal bed in the Pennsylvanian system of a certain part of Illinois reach essentially its present condition by the close of the Paleozoic era, or at any other fairly specific past geologic date, or must we consider that it has only recently reached its present rank and is still undergoing important change, be it ever so slow? It seems probable that such a question can now be answered definitely for given coal seams in certain areas, and that if criteria be assembled and coal-bearing strata studied with these problems in mind, additional worth-while results will be obtained.

Causes of coalification.—It seems true that the only everlasting thing is change, and that alteration of materials results from the constant variation in environment which prevents attainment of anything but a geologically temporary state of equilibrium at best. We thus expect that coalification might have occurred rapidly in those situations where environmental change was rapid, and vice versa. We know that in some cases coalification has been exceedingly slow or at least has never proceeded very far; thus our oldest very extensive coals, those of the Moscow Basin in Mississippian strata, are of lignitic rank. But do we know cases of an opposite nature, always excepting those where igneous metamorphism has been of obvious or suspected importance?

Significant Examples.—Rounded coal pebbles found in sediments in close association with the seam from which they were probably derived indicate that the embryo coal early reached a stage in the coalification process in which it was brittle. This would hardly be short of the lignite stage, and might be closer to sub-bituminous, depending of course on the amount of moisture present. Considerable significance should possibly be attached to the question of whether a given coal pebble shows the effects of definite subsequent differential compaction as compared to that of the matrix sediments, especially if these are not shaly. Examples illustrative of these points may be taken from the literature covering Great Britain, Germany, France, Poland, Ohio, and West Virginia.

Sandstone dikes cutting coal seams in Utah and Illinois are described. These indicate that the embryo coal was brittle enough to crack before consolidation of the superjacent sandstone, and that subsequent to consolidation of the sand of the dikes there has been no important differential compaction between coal and sandstone dike.

Other criteria, such as folding in a coal-bearing series due to largely contemporaneous differential compaction below a channel sandstone, and the relations of partings and splits to the coal seam, are cited as significant in this connection.

Conclusions.—It seems clear that there is strong evidence that coalification may under certain conditions proceed with great rapidity, geologically speaking, even away from the igneous contact environment. Coals of

bituminous rank occur in the Miocene of California and in the Oligocene, even though not intensely folded nor deeply buried, in Czecho-slovakia (Gonobitz and Schega), western Rumania (Zsil valley in Siebenbürgen), and Sumatra. Sub-bituminous beds of Miocene age are not very rare. Anthracites of Eocene age occur in highly folded rocks of Switzerland (Diablerets) and Thrace (Sulfili).

While no one will question the fact that increased pressures and temperatures may be important agents of the coalification process, the burden of proof rests on those who say that these are the sole ones, as is shown by the evidence cited. Each seam in a given area should be examined and its origin interpreted in light of its own field and laboratory evidence.

The theory of progressive regional carbonization, first emphasized by David White, who considers that lateral pressure is the most important agent of coalification, receives important modification if the evidence here presented is granted to demonstrate early coalification in at least some cases. It follows from this that coal can form without the action of significant lateral pressures and with only minor load pressures. Moreover neither long time intervals nor important increases in temperature would seem to be necessary.

It has been suggested that syneretic changes may be a possible explanation of the phenomenon; careful observation and experimentation are needed to clear up many details. In especial, if this is on the right track, one would like to know why there is so much lignite. Is syneresis so exceedingly slow? Time is not the only factor, as is certainly shown by the Moscow Basin lignites. Has pH value been an important control? This and many other possible factors need investigation. The McKenzie Taylor theory of base-exchange (substitution of sodium) in roof strata with subsequent hydrolysis giving alkaline conditions, and so permitting long-continued bacterial action, thus controlling rank of coal, seems to fall down when examined closely on the following counts: lack of satisfactory evidence that hydrolysis has occurred (sodium clay is particularly impervious to water, though less so to dilute solutions of calcium salts); general but not universal agreement that bacterial action insofar as it is important in the coalification process is limited to the peat stage; and, at least for the higher coal ranks, evidence brought out in connection with the theory of progressive regional carbonization.

That the latter theory is at least partially applicable to the post-sub-bituminous stages is not questioned. In short so far as devolatilization is concerned, the theory has much to recommend it. But that important lateral pressure is unnecessary to account for the early dehydration of coals (down to a moisture content of 20 per cent or less, ash-free basis), is a major tenet of this paper. Advocates of the theory as applicable to the earlier stages of coalification can hardly substantiate their positions by studies in areas of higher ranks. As a matter of fact it is in just such areas that most of the field evidence cited in this paper has been obtained.

Possible Relations of Mineral Matter in Coal to the Time of Coalification

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The results of detailed petrographic investigations of visible mineral matter in Illinois coals, while not complete, are nevertheless sufficiently conclusive to justify certain generalizations in regard to the identity and occurrence of the component minerals.

It has been observed[1] that the mineral matter separable from coal consists of (1) those minerals which were washed, blown or otherwise transported into the coal basin during the time of peat accumulation, consisting mainly of detrital clay and small amounts of minerals similar to those in the associated sediments, and (2) those minerals deposited from solution or suspension in the interstices of the bed after the coal was buried. Minerals of the second group are generally restricted to pyrite, kaolinite, and calcite. The characteristic occurrences of kaolinite and calcite in coal permit definite establishing of time relationships in their deposition.

THE OCCURRENCE OF KAOLINITE AND CALCITE IN COAL

1. Original openings.—Those natural openings which existed in the plant at the time of deposition in the peat or which were developed within the peat-forming constituents during or very soon after peat accumulation are here considered as original openings. The most prominent constituent of coal which possesses such original openings is fusain. Another naturally porous ingredient in coal, closely related to fusain, apparently represents a transition stage between vitrain and fusain. This form has been named "bogen" structure.

In general, both of these coal constituents are mineral-filled, usually with kaolinite. Calcite has been observed in some fusain lenticles, however, usually appearing in the larger and more centrally located cavities, while the smaller and marginal openings of the same lenticle are filled with kaolinite.

Of frequent occurrence in fusain partings and in the clarain bands are tiny, elongated cylinders which have been interpreted as resin rodlets. When partially or completely hollow, these rodlets are generally filled with kaolinite.

Small, irregular openings which may have been inherent to some particular plant are sometimes seen in vitrain bands. These are filled with kaolinite. Spores are occasionally observed with kaolinite fillings, although such occurrences are rare. Small structures with quartz-filled cavities are found to some extent in vitrain and clarain and may represent the medullary rays of certain plant varieties.

2. Desiccation cracks.—Desiccation cracks in Illinois coals are characteristic of and commonly restricted to vitrain bands.[1] In most Illinois

[1] Ball, C. G. The mineral matter of No. 6 bed coal at West Frankfort, Franklin County, Illinois: Illinois State Geol. Survey Report of Investigations No. 33, 1935.

coals the desiccation cracks have been filled with kaolinite, especially the fine cracks occurring in the thinner vitrain bands. Calcite may be present in desiccation cracks, particularly in high-calcite beds, or in distinct portions of any single bed which contain abundant calcite. These calcite fillings are in general thicker than those formed of kaolinite, and may even occur in the same cracks with kaolinite. In such cases the calcite usually slightly overlaps the kaolinite, suggesting that desiccation was not complete at the time of deposition of the kaolinite.

3. **Fracture cracks.**—Fracture cracks in coal are those cracks extending across one or more of the banded constituents, either vertically or at nearly vertical angles to the bedding. The oblique or zig-zag pattern often characteristic of the fracture cracks is thought to show evidence of dynamic strain within the coal bed, although the apparent lack of displacement either in the lithologic constituents of the coal or in the mineral-filled desiccation cracks suggests that the stress was very slight. These cracks are filled dominantly with calcite. The calcite, moreover, seems to be definitely post-kaolinite in age. Fracture cracks, filled with calcite, may cross and horizontally displace fusain lenticles already filled with kaolinite. They may widen and overlap kaolinite-filled desiccation cracks.

TIME OF COALIFICATION

With the above relationships in mind, a tentative summary of part of the coalification process is offered for consideration. It is suggested that deposition of kaolinite in the original openings of the coal took place shortly after, if not actually during, the process of peat accumulation. The fact that the porous fusain lenticles and resin rodlets were not crushed and broken prior to kaolinite deposition, and that the constituents of the clarain are frequently bent and distorted downwards around these ingredients is strongly suggestive of early kaolinite infiltration. This can not be considered as direct evidence, it is true, since the inherent strength of the fusain and resin rodlets may have been sufficient to resist crushing without the support of mineral fillings.

If it be assumed that the original cavities were filled shortly after peat deposition, it would appear that the desiccation cracks were formed and mineralized at a similarly early stage in the coalification process, since the natural openings in coal and the desiccation cracks are both kaolinite-filled. The pattern of most desiccation cracks is so strongly suggestive of the drying-out of a gel-like material, undisturbed by structural movement, that it is believed the kaolinite deposition took place before the coal bed had suffered any dynamic movement, unless the coal had retained its peat-like plasticity for a long period of time.

The fracture cracks are believed to represent the effects of some form of stress other than vertical compression. The origin of the pronounced cleating in coal has not been considered here, but it is believed that this jointing took place at a period later than the formation of the fracture cracks. It is possible that the cleat would most logically represent the results of the late Paleozoic dynamic movements, while the minor fracture joints were formed by previous and less extensive movements such as concluded a megacyclothem.

Status of the Carbon-Ratio Theory in Illinois

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According to the carbon-ratio theeory, dynamic metamorphism increases the percentage of fixed carbon in coal and the Baumé gravity of oil until a limit or "extinction zone" is reached beyond which oil does not exist in liquid form at ordinary temperature and pressure. The sequence of variations in average carbon-ratios (per cent fixed carbon in moisture- and mineral matter-free coal) of the coals and in the average gravities of the oils in going from a region of relatively undisturbed rocks to one that has been highly disturbed is believed to be indicative of the progressive change in these properties of the coal and oil in a locality structurally disturbed since their deposition.

The pertinent data on coal and oil in Illinois are reviewed and their bearing on the carbon-ratio theory is discussed. Progressive increase is noted in the carbon-ratios in going from the northern to the southern part of the Illinois coal basin. In the extreme southern part there is an east-west belt of faulting and some igneous intrusion. However the stage of dynamic metamorphism reached here is far short of that reached in the folded areas of the Appalachian mountains. The highest carbon-ratios in Illinois are approximately 62 per cent which is in the extinction zone for oil, announced in a recent paper by David White as from 61 to 63 per cent. The range in degree of dynamic metamorphism in Illinois is, therefore, insufficient for a complete test of the carbon-ratio theory.

The isocarb maps prepared during this investigation are based on more data than similar maps prepared by Moulton in 1925. They do not entirely support his conclusion that the isocarbs parallel the structure contours.

Study of oil gravities in Illinois with respect to their areal distribution does not reveal any relation either with the variations in carbon-ratio of coals or with degree of regional dynamic metamorphism. The known variations in oil gravity seem to depend largely on geologic age of the oil-bearing rock and on depth of burial. The majority of the known oil fields are located on or near carbon-ratio "highs" and therefore knowledge of carbon-ratios may be of some value in future prospecting for new oil fields.

Temperature During Coal Formation

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The more important factors influencing the degree of metamorphism of coal are pressure, temperature, type of cover, and the time through which these factors act. From all considerations temperature is probably the most important factor influencing the rank of coal. What the maximum temperatures were to which a given coal was subjected has been the subject of much speculation and some not very conclusive research. In general, students of the subject have come to two different conclusions. One group believes that rather high temperatures, that is, 200° C. for brown coals and 300 to 350° C. for bituminous coals, were responsible; the other group is inclined to believe that relatively low temperatures were effective. The present author holds to this latter view.

The evidence put forth for the high temperature view is based largely upon the minimum temperatures required to cause visible or measurable changes to coal in laboratory tests. B. Newmann,[1] for example, on the basis of the softening point of the resins, places the temperature to which a Chinese bituminous coal and a Westphalian high volatile coal were subjected at 265-320° C. and 230-300° C. respectively. His conclusions are based upon an assumption that the rounded shape of the resins in the coal is a proof that the resins had been subjected to temperatures equal to their melting points. The argument is inconclusive since resins will flow at very low temperatures under the influence of pressure. The temperature at which coals begin to evolve decomposition products does not necessarily bear any relationship to their previous thermal history. Many organic compounds, synthetic and natural, behave similarly to coal when subjected to heat. That temperatures of 300° C. are required to produce artificial "coalification" of organic material in the laboratory is also regarded as incomparable with natural conditions of coalification.

The author believes that: (1) The behavior, under the microscope, of coal when heated, (2) the behavior of moisture in coal, (3) the temperatures at present associated with coal beds, (4) the properties of coals which have been subjected to higher temperatures brought about by igneous intrusions, and (5) the rate of increase of chemical reaction rates with temperature increase, are sufficient evidence to prove that the maximum temperatures during the formation of bituminous coals was not greatly in excess of those found today in coal beds, certainly not much greater than 100° C.

R. Thiessen[2] has shown that at 150° C., dark-bordered cracks appear in the anthraxylon bands of bituminous coal, and that at 330° C. vacuoles appeared in certain leaf tissues. We conclude from this that bituminous coal had not previously been subjected to temperatures higher than 150° C.

Coal moisture is largely held colloidally. A coal will not reabsorb as much moisture as it loses on drying. It is difficult to account for the high moisture content of Illinois bituminous coals if one assumes that they have been subjected to temperatures far above the boiling point of water.

[1] Newmann, B.—Brennstoff-Chemie *15* (2): 25-7 (1934).
[2] Thiessen, R. and Sprunk, G. C.—Fuel *13* (4): 116-125 (1934).

Coal formation is apparently taking place today. We find all ranks of coal represented, from young peats to anthracites, yet nowhere do we find unusual temperatures associated with these beds. Present geothermal conditions do not lend much evidence to support the theory that coal formation depended upon high temperature. However, in certain localized areas, igneous intrusions have resulted in relatively high temperatures. Under such conditions, the coal in contact with the intrusive material has been greatly altered. Here, where we do have a definite condition of high temperature, coalification has taken a different course than in the rest of the deposit.

Finally, the rate of change of chemical reaction rates with temperature changes lends further support to the idea of low temperatures. The rate of a chemical reaction roughly doubles for each 10° C. rise in temperature. On that basis, a reaction should go the same amount in ten days at 320° C. as in thirty million years at 20° C. High temperatures result in coalification (polymerization, decomposition, and dehydration) rates which are far too high.

The author concludes, therefore, that normal coalification occurred at relatively low temperatures, that is, at approximately those found today in coal beds.

Local Calorific Variations in Coal No. 6 and the Geological Implications*

E. T. Benson

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The area under discussion lies in southern Illinois south of T. 3 N., and west of R. 5 E. In this area No. 6 coal is the most extensively mined coal, so its structural features and chemical character are relatively well known. No. 6 coal averages more than 6 feet in thickness throughout the area, and attains thicknesses as great as 15 feet in small areas.

In the northwest part of the area the structure of the coal is without notable features, gentle regional dip to the east and north being characteristic. In the southern part of the area three belts of structural irregularity are prominent. They are: (1) The DuQuoin anticline, or monocline, which extends from northern Jackson County northward to the Centralia-Sandoval region. This flexure is most prominent in Jackson and Perry counties; (2) a zone of structural irregularity consisting of faults and reverse dips extending from T. 8 S., R. 4 E., in Williamson County westward to T. 7 W., R. 1 W., in Jackson County. This faulted belt is along the eastward projection of the Campbell Hill Anticline[1] and the westward projection of the Cottage Grove or Harrisburg[2] fault; (3) a minor belt of deformation consisting of faults and reverse dips extending slightly west of north from central Williamson County up into central Franklin County.

The chemical character of No. 6 bed coal in the area under discussion is interpreted from the analyses of 437 face samples collected from 103 mines. The calorific values of the coal are given on the unit coal basis,[3] which is essentially a moisture and mineral-matter-free basis. This is used in order to do away with irregularities which might be caused by variations in moisture and mineral matter content. Isocalorific lines are drawn through points having equal calorific value. The distribution of the lines with respect to the structure contours should indicate whether calorific value has any relationship to structure.

In Franklin and Williamson counties it can be seen from the map that the 14,600 unit B. t. u. line entirely surrounds the area where structural deformation of the coal has occurred. The faulting and folding has apparently taken place after the consolidation of the coal, and the stresses involved in the deformation have apparently so affected the coal that its calorific values are higher than in the areas where such deformation is not prominent or entirely absent. An example of this latter condition is the western half of the area shown on the map. Here the structure is gentle and featureless, and the calorific values are fairly regular in their distribution and bear no apparent relationship to structure.

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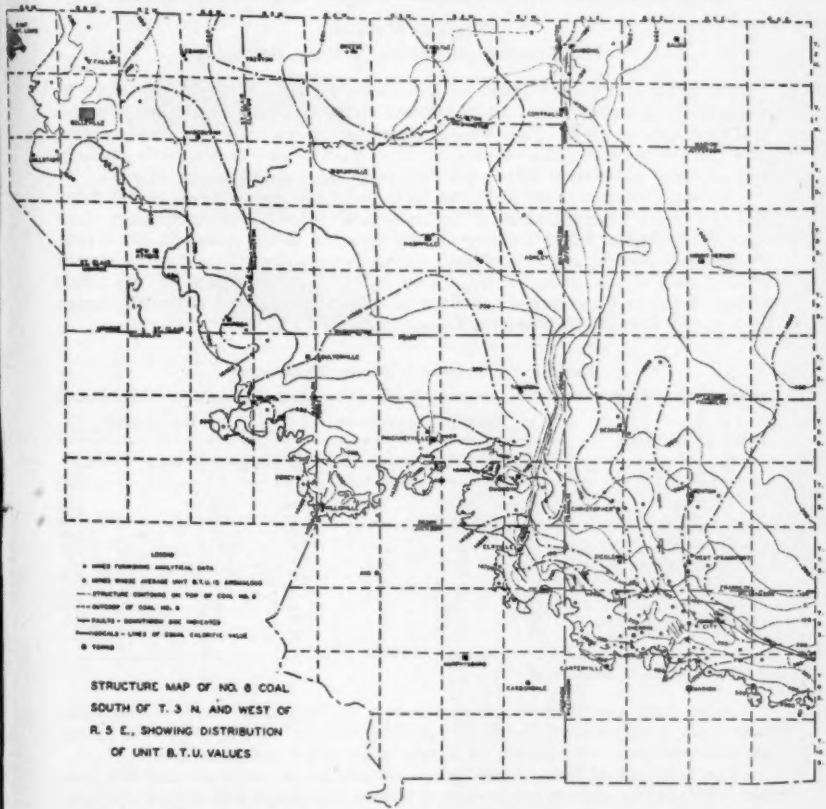
* Presented by permission of the Chief, State Geological Survey.

[1] St. Clair, Stuart, Oil Possibilities of the Ava Area, Illinois State Geol. Survey Bull. 35, pp. 57-65, 1917.

[2] Cady, G. H. Coal Resources of District V, Illinois State Geol. Survey Coop. Bull. 19, p. 31, 1919.

[3] Parr and Wheeler. Unit Coal and Composition of Coal Ash, University of Illinois Eng. Exp. Station Bull. 37, 1909.

It was formerly thought that the DuQuoin anticline marked a distinct change in the character of the coal. This is not demonstrated by the present study, for the isocalorific lines cross this structural feature with little or no apparent relationship to the deformation. The 14,400 and 14,500 B. t. u. lines roughly parallel this flexure, but there is no abrupt increase in calorific value of the coal where the structure is prominent. This suggests that the DuQuoin anticline existed as a structural feature prior to or contemporaneously



STRUCTURE MAP OF NO. 6 COAL SOUTH OF T. 3 N. AND WEST OF R. 5 E., SHOWING DISTRIBUTION OF UNIT B.T.U. VALUES

with the deposition of No. 6 coal, and that subsequent movements along this line of deformation occurred before the coal bed was consolidated, and therefore did not effect changes in the character of the coal itself. There is other evidence available to substantiate this time relationship of the structure and coal deposition, but space does not permit its presentation here.

The calorific value of No. 6 bed coal is undoubtedly affected locally along the outcrop by being excessively wet or dried out. Variations arising from these conditions have not been considered here.

Blue print enlargements of the map are available upon request to the State Geological Survey, Urbana.

Significance of Banded Ingredients in Coal*

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In 1931 the coal division of the State Geological Survey began an investigation of the physical and chemical characteristics of the bands which make up Illinois coals. Information subsequently collected has demonstrated that the three banded ingredients, vitrain, clarain, and fusain have chemical and physical differences which are significant in the utilization of coal.

To date columns have been cut from the seam in 46 mines in the State and the relative percentages of the important ingredients have been carefully determined. Table 1 shows the distribution in ten mines in No. 6 coal. Vitrain and clarain are to a certain extent complementary and make up the greater part of the coal. In No. 6 coal in the southern part of the State vitrain becomes progressively greater in quantity from the Belleville region toward the Franklin-Williamson County district (Fig. 1).

TABLE 1—PERCENTAGES OF BANDED INGREDIENTS

Mine	County	Banded coal ingredients				Banded impurities		
		Vitrain	Clarain	Durain	Fusain	Pyrite	Bone	Clay
A	St. Clair	13.16	76.51	----------	3.38	5.12	----------	1.83
B	St. Clair	7.83	83.09	----------	2.62	4.76	----------	1.70
C	St. Clair	9.95	77.58	----------	7.43	1.82	1.33	1.89
D	Montgomery	19.5	62.1	14.9	.8	1.5	----------	1.2
E	Washington	13.40	68.70	15.0	2.9	----------	----------	(a)
F	Randolph	14.76	75.88	----------	4.77	----------	----------	4.59
G	Perry	19.00	69.90	----------	4.50	----------	2.6	4.00
H	Franklin	18.81	77.68	----------	1.50	.42	.61	.98
I	Franklin	22.70	72.40	----------	2.3	.10	1.60	.9
J	Williamson	20.1	76.55	----------	1.35	----------	2.0	----------

(a) Eight-inch clay band removed in mining.

Some sixty analyses of bands are now available and some conclusions concerning differences in chemical character may be drawn. Figure 2 shows the characteristics of samples of bands taken from the same mine.

The analyses of fusain show great variability in moisture and ash content. Within the same mine, moisture values vary from 8.99 to 22.8 per cent and the ash from 4.86 to 16.91 per cent. This variability in moisture and ash content is due to the porous nature of the fusain; air drying loss is for the same reason very high. Other noteworthy chemical peculiarities of fusain are a very high content of fixed carbon, which in the dry, ash-free coal is about 75 per cent, so that the fuel ratio $\frac{(FC)}{(VM)}$ is commonly more than 3.0. The unit coal value of fusain is fairly constant at about 15,000 B. t. u., although there are erratic and unexpected variations from this value.

Vitrain is generally characterized by less ash than the other ingredients

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Fig. 1 *(Left)*.—Map showing distribution of vitrain in southern Illinois.
Fig. 2 *(Right)*.—Content of volatile matter, fixed carbon, and ash in samples of vitrain, clarain, and fusain, and the B.t.u. values of the same banded ingredients.

(0.49 per cent ash samples have been collected) and a relatively low unit coal value. The composition of clarain does not differ markedly from the raw coal. The fuel ratio of clarain and vitrain is much lower than that of fusain, but in samples from the same mine the fuel ratio of clarain is found to be lower than that for vitrain. In general there is an increase in the fuel ratio for the bands as well as for the raw coal southeastward across the southern part of the State.

The proportion of these ingredients in a coal is of utmost importance in many industrial processes which require carefully controlled fuels. Vitrain swells more than clarain when it is heated. Fusain is non-coking. Stach states that vitrain is suited to coking, clarain to liquefaction and carbonization and mineral charcoal to fuel-dust firing.

The desirability of mechanically separating or concentrating the different ingredients becomes apparent with the realization that a single ingredient or a particular blending of ingredients may more satisfactorily meet a certain fuel requirement than the coal as it is recovered in mining. Table 2 shows the amount of concentration attained in standard washability tests. The

TABLE 2—SPECIFIC GRAVITY DISTRIBUTION OF BANDED INGREDIENTS IN SAMPLE FROM MINE J
(Per cent by volume)

Specific gravity	Vitrain	Clarain	Fusain	Mineral matter
1.30 float	10.7	4.3	trace	.0
1.35 float	6.1	20.1	trace	.0
1.40 float	2.2	34.3	trace	.0
1.50 float	.8	12.2	.1	.2
1.70 float	.3	2.1	.1	.3
2.00 float	.2	1.0	.1	1.5
2.00 sink	.2	.9	.1	2.2
Total	20.5	74.9	.4	4.2

ingredients were so distributed that the 1.3 specific gravity fraction contained 52.2 per cent of the total vitrain in the sample, 71.3 per cent of the fraction being vitrain. The fractions of 1.35 to 1.70 specific gravity contained 91.7 per cent of the clarain. Fusain was largely removed in the minus 48 mesh dust which was screened out before the tests were run. Comparable separation no doubt takes place in many of the cleaning plants recently established in Illinois for cleaning fine coal though at this time actual separation is confined to ash and undifferentiated coal.

Sizing concentrates the ingredients to a considerable degree. In investigation of screenings it has been found that the 1¼ x ½ inch coal is largely clarain. Vitrain, because of its friable nature, tends to concentrate in the ½ inch x 48 mesh fractions and is at a maximum between 10 and 48 mesh. The minus 48 mesh dust is relatively high in fusain which in some instances may be as high as 60 to 70 per cent.

As with ores, differential flotation of coal may be effected in some instances. Chapman found that with kerosene certain British coals produced froths containing 76 per cent vitrain and 24 per cent clarain and when phenol was used the froths contained 80 per cent clarain and 20 per cent vitrain. Price has found it possible to depress clarain by adding organic colloids such as starch without affecting the flotability of vitrain.

The ability to control the nature of the coal reaching the market is particularly significant as: (1) It permits close control over coking mixtures; (2) segregation of those parts of the coal best suited for liquid and gaseous fuels is possible; (3) blending to produce satisfactory burning characteristics in stoker fuels is in many instances necessary; and (4) isolation of easily pulverized ingredients for powdered fuels is desirable.

"Grassy Creek" Shale*

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The name Grassy Creek was originally proposed by Keyes[1] for a series of "black and green shales", which have also been called Hamilton shale by Rowley,[2] supposedly lying between the Silurian and Louisiana limestones in Pike County, Missouri, and said to achieve their greatest development in the drainage basin of Grassy Creek. Later Keyes restricted this name to the lower, hard, black, sheety beds occurring in this interval and proposed the name Saverton[3] for the upper greenish or bluish shale. Some subsequent authors have concluded that the subdivision of these shales into two formations is unjustified because they grade both vertically and laterally into one another and they have continued to apply the name Grassy Creek to the entire interval.

Keyes did not definitely designate a type locality for the Grassy Creek shale. Branson and Mehl[4] have concluded that Louisiana is the type locality, apparently because this place was mentioned before Grassy Creek, but others have believed that the latter locality must be considered the type because it is there that this shale was said to achieve its greatest development and because it received its name from that stream.

Keyes' knowledge of the stratigraphy of Pike County was obtained largely from Rowley who had explored its hills and valleys from early boyhood. The fact that Rowley included in his Pike County report a photograph and columnar section of the "Hamilton" shale as exposed on Grassy Creek near the center of section 19[5] is evidence that this is probably the best exposure of the shales in this vicinity and this conclusion is substantiated by a day's field work which failed to reveal any other outcrops of comparable perfection. This outcrop, therefore, was probably considered by him to be the best exposure of this part of the section. Under these circumstances it seems logical to assume that this best exposure of Rowley's "Hamilton" shale is likewise the type outcrop of Keyes' Grassy Creek shale.

An effort to establish the precise type locality of the Grassy Creek shale would be superfluous were it not for the fact that the so-called Grassy Creek shale at Louisiana is not equivalent to the Grassy Creek shale on Grassy Creek. Krey[6] was the first to discover that the Silurian limestone is absent in section 19 and that the lower, lighter gray shale, not distinguished from the overlying darker beds by Rowley, is typical Maquoketa. Later Banson and Mehl[7] independently determined the Maquoketa age of these lower shales as a result of their conodont studies but they differ from Krey in their correlation of the overlying strata.

The section exposed in the south bank of Grassy Creek near the center of section 19, T. 54 N., R. 2 W., is as follows:

		Thickness Feet
5.	Louisiana limestone, many fragments, stratum not seen in place	.....
4.	Covered interval	.....
3.	Shale, light bluish-gray, argillaceous, weathering to light greenish-gray clay	15 to 20
2.	Shale, dark gray, rather hard with abundant liguloids and fragments of graptolites—at top and bottom are very fine grained sandstone layers	about 10
1.	Maquoketa shale, medium gray, slightly bluish, thickly bedded with discontinuous, irregular, thin layers of earthy gray limestone in upper part	about 30

Branson and Mehl[8] correlate the dark shale, member 2, with the black shale (Grassy Creek restricted) at Louisiana. Krey[9] states that this shale

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overlies the typical Maquoketa unconformably but underlies the horizon of the Silurian limestone which is locally absent and concludes that its age is either early Silurian or late Maquoketa. This member does not resemble the black shale at Louisiana as it is not black but dark gray, nor is it sheety or fissil but somewhat imperfectly laminated like a more ordinary type of shale.

Branson and Mehl[10] state that they have collected "Grassy Creek" conodonts from the shales in section 19 on Grassy Creek but in none of their systematic descriptions is any reference made to this locality. We may conclude, therefore, that probably the conodont fauna obtained at this place was very scanty or poorly preserved and perhaps was not sufficiently diagnostic for an accurate age determination. Scepticism regarding their statement is occasioned by the occurrence of fragmentary graptolites in the dark shale member. Such fossils have not previously been noted at this locality nor have they been reported anywhere in the upper Mississippi valley from beds of lower Kinderhook age. In addition Branson and Mehl do not record the horizon in the Grassy Creek section from which their conodonts were collected and if their specimens actually are indicative of "Grassy Creek" age they almost certainly came from above the dark shale of member 2.

Another exposure located about one mile to the northeast, in the southwest ¼ of section 17, shows member 3 of the Grassy Creek section overlain by a layer of hard brown sandstone 2 to 4 inches thick containing abundant fish teeth. This bed is quite similar to the fish bearing sandstone at the base of the Kinderhook at Louisiana and is further evidence that the entire section exposed in section 19 is pre-Kinderhook and that the "Grassy Creek" shale, reported by Krey[11] to be 5 to 10 feet thick in this vicinity, occupies the covered interval below the slumped Louisiana limestone. The greenish shale, member 3, which is not mentioned in Krey's report, is quite different from the main part of the Maquoketa of Pike County and was correlated with the Saverton shale by Keyes but it closely resembles the uppermost Maquoketa of Calhoun County, Illinois, to which it probably is equivalent.

The confusion that has resulted from the misinterpretation of the Grassy Creek section seems to necessitate a redefinition of formations. The simplest solution is to relinquish the name Grassy Creek for the basal black Kinderhook shale. If it is desirable, this name might be redefined and applied to the dark shale member in the upper part of the Maquoketa. At the present time it does not seem advisable to distinguish the basal black shale from the overlying greenish or bluish beds and it is therefore proposed to expand the Saverton formation to include the basal Kinderhook black shale exposed in the vicinity of Louisiana which has been known formerly by the name Grassy Creek.

1. KEYES, C. R., Some geological formations of the Cap-au-Gres uplift, Proc. Ia. Acad. Sci., vol. 5 (1898), p. 63.
2. ROWLEY, R. R., The geology of Pike County, Mo. Bur. Geol. and Mines, ser. 2, vol. 8 (1908), p. 24.
3. KEYES, C. R., Marked unconformity between Carboniferous and Devonian strata in upper Mississippi valley, Am. Jour. Sci. ser. 4, vol. 36 (1913), p. 160.
4. BRANSON, E. B., and MEHL, M. G., Conodonts from the Grassy Creek shale of Missouri, Univ. of Mo. Studies, vol. 8, No. 3 (1934), p. 171.
5. ROWLEY, R. R., op. cit. pl. 8; fig. 8, p. 25.
6. KREY, FRANK, Structural reconnaissance of the Mississippi valley area from Old Monroe to Nauvoo, Illinois, Ill. State Geol. Surv., Bull. 45 (1924), p. 23.
7. BRANSON, E. B., and MEHL, M. G., Conodonts from the Maquoketa-Thebes (Upper Ordovician) of Missouri, Univ. of Mo. Studies, vol. 8, No. 2 (1933), p. 122.
8. BRANSON, E. B., and MEHL, M. G. op., cit. (1934), p. 173.
9. KREY, FRANK, op. cit., p. 23.
10. BRANSON, E. B., and MEHL, M. G., op. cit. (1934), p. 176.
11. KREY, FRANK, op. cit., p. 34.

Geological Setting of the Aurora Mastodon Remains

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Since March, 1934, excavation for a municipal lake in Phillips Park, Aurora, has yielded remains of a surprising assemblage of now extinct animals. Among these remains are three skulls of the American mastodon, three tusks, a lower jaw, and other smaller parts of the same animal, together with bones belonging to the trumpeter swan, giant beaver, deer, elk, bear, and other animals. These bones have been carefully studied by Professor Clarence R. Smith of Aurora College. Largely through his work, they have become well known to the local public and have aroused large popular interest.

The area from which these remains were taken is a peat bog in the southeastern part of Aurora. Part of the bones came from the peat itself, but practically all the bones of the mastodon and trumpeter swan were found in the upper part of shell marl that underlies the peat. The flat bog lies between a high rolling ridge, the Minooka glacial moraine, on the east, and a flat terrace of gravel on the west. The gravel terrace stands 50 to 60 feet above the Fox River and evidently marks a period when the Fox River valley was filled with gravel to the level of the present terrace top. Later, the river ceased depositing gravel and eroded its valley to its present level. The peat bog is about one mile long by four-tenths of a mile wide. Irregular salients and reëntrants in the western margin of the bog suggest that the gravel terrace was built as a series of overlapping bars that blocked the drainage of the somewhat lower area now occupied by the bog. The excavation made during the last 15 months is a triangular area about 500 yards long by 300 yards wide, and four to six feet deep.

The peat is a fibrous mass of the grass or *carex* type. It attains a maximum thickness of about six feet, and everywhere except at the edges it rests on shell marl. The peat is rudely stratified in more fibrous and less fibrous layers. In certain thin layers near the base small molluscan shells similar to those in the marl are rather numerous; not throughout the whole bog, but in definite belts that probably mark old stream channels across the bog.

Beneath the peat is white to light gray marl known to attain a thickness of 30 feet. The marl is well stratified and consists of the shells of small gastropods and pelecypods in a limy matrix. Dr. F. C. Baker of the University of Illinois has identified the following genera and species:

Anodonta species.
Pisidium species.
Valvata tricarinata (Say).
Valvata tricarinata perdepressa Walker.
Valvata tricarinata unicarinata DeKay.
Valvata tricarinata infracarinata Vanatta.
Valvata tricarinata simplex Gould.
Valvata sincera illinoisensis F. C. Baker—Not known living.
Amnicola leightoni F. C. Baker—Not known living.
Amnicola walkeri precursor F. C. Baker—Not known living.

Amnicola greenensis F. C. Baker—Not known living.
Lymnaea stagnalis jugularis Say.
Fossaria obrussa decampi (Streng).
Helisoma anceps striatum (F. C. Baker).
Helisoma campanulatum (Say).
Planorbula armigera (Say).
Menetus exacuous (Say).
Gyraulus altissimus (F. C. Baker).
Physa integra Haldeman.
Physa species.

The thickness of 30 feet was attained in one of a series of test holes in a north-south line across the bog. In other holes depths of 13, 16, and 18 feet were recorded, and from one of these a strong odor of hydrogen sulfide was emitted. The mastodon and swan remains were taken from the upper few feet of this marl.

Geological interest in these vertebrate remains centers about their age and the conditions of their entombment. The peat, which contains the bones of deer, bear, and perhaps even animals buried by man, cannot be more than a few hundred years old. A common estimate for the rate of peat accumulation in a fresh water marsh is two feet per hundred years. However, Capps has proved that a certain deposit of peat in the White River valley, Alaska, has accumulated at the rate of only one foot in 200 years.[1] If these two estimates be taken as extremes, the six feet of peat in Phillips Park bog accumulated in from 300 to 1200 years.

The marl accumulated in a fresh water lake between the Minooka moraine on the east and a gravel terrace on the west. The terrace is one of a series that rise at the rate of about five feet per mile as one ascends the Fox River, only to end at the West Chicago or outermost Valparaiso moraine near Algonquin. These terraces clearly are a valley train formed as outwash during the West Chicago ice-stand. Therefore the lake at Phillips Park originated in the early part of the Cary substage of the Wisconsin glaciation, when the glacier first began its final retreat from the region.

Dr. Baker reports that the fauna of the marl indicates a cold-temperate climate, and is "quite like the marl fauna found a few years ago in the bottom of Green Lake, Wisconsin, which is certainly Middle Wisconsin in age, not later."[2] This interpretation of the climate is further supported by the occurrence of hemlock and spruce cones in association with the mastodon remains, and by the proportions of coniferous and deciduous pollen in the marl itself. Although these evergreens do not now occur as native forest trees in this region, their cones are found in the marl, and a count of pollen grains washed from the upper part of the marl showed 20 per cent coniferous pollen, 80 per cent deciduous. These facts indicate that the climate was considerably cooler, though not glacial, during the time when the upper part of the marl, was deposited. It is likely that the mastodon remains were buried only a few thousand years ago.

The fact that the bones were inarticulate and rather widely scattered in the marl indicates that these animals did not drown or become mired in the lake. Rather, they probably met their death on the banks, perhaps in winter, when their bones would have been scattered on the frozen lake surface by wolves or other carnivorous animals. With the melting of the ice, the bones must have dropped into the marl where they remained to the present time.

[1] Capps, S. R., Glaciation in Alaska: U. S. Geol. Survey, Prof. Paper 170 A, pp. 5-6, 1931.
[2] Baker, F. C., Personal communication.

Mastodon and Other Finds at Aurora

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Finding the remains of mastodon and other forms of life in an old bog at Aurora has furnished a glimpse of that locality in a more or less fragmentary sequence from early post-glacial times down to the present.[1] The locality is within the limits of Phillips Park in Aurora and about a mile and a half east of the Fox River. The bog itself is surrounded on three sides by hills of glacial till, and the formation consists of a deep deposit of gray marl surmounted by a layer of peat, in turn covered by a layer of black muck which has comprised the bottom of the modern swamp.[2] The specimens were found by CWA workmen while excavating for an artificial lake.

The mastodon parts were found in the upper 3 feet of the marl deposit and consist of three skulls (one including the mandible), three tusks, a scapula, an ulna, a femur, a number of vertebra, ribs, and several foot bones. In color the bones were brownish-yellow to brown and were in a good state of preservation except for the scapula and one skull which were very fragile. One skull measured 46½ inches long and 28½ inches wide. Two of the tusks appeared to constitute a pair, nearly white in color, of similar curvature and lengths—8 feet 2 inches and 8 feet 3 inches. The third tusk was not well preserved and broke into three pieces during exhumation. Mr. E. S. Riggs, paleontologist at the Field Museum of Natural History in Chicago, identified the species as *Mastodon americanus*.

For preservative treatment the mastodon bones were saturated with the following mixture: Varnish having 100 per cent bakelite base 70 cc., turpentine 18 cc., raw linseed oil 10 cc., and oil of wintergreen 2 cc. The use of bakelite varnish for fossils is not new; the other ingredients were added after experimentation by the author. It was hoped that the penetrating properties of oil of wintergreen would be an advantage with dense materials such as tusk ivory and teeth. The mixture is more efficacious than shellac in hardening fossil bone and in retarding the cracking as the bone dries and shrinks.

At the pulp end of the two better preserved tusks were a series of six or eight faint ridges or so-called "growth rings". Such rings have been mentioned by Kunz[3] and others but their true significance is uncertain. However, if we entertain the possibility of their representing years of growth, the figures are interesting. The average width of the rings is 62 mm., and assuming uniformity for the entire length of the tusks, would represent the age of the animal as 41 years. Within each of the wide rings is a series of about seven narrower rings of differing widths, and in any two adjacent wide rings these secondary ring patterns are remarkably similar. This seems to support the theory that the wide rings represent yearly growth and that the secondary pattern represents a physiological response to change in weather, abundance of food, kind of food, etc., within the year.

[1] Smith, Clarence R., Science 81:379 (April 19, 1935).
[2] Powers, William E., Geological setting of the Aurora Mastodon remains, this volume, p. 193.
[3] Kunz, George F., Ivory and the Elephant (New York, 1916), p. 399.

In the north area of the marl deposit were found at about the same level as the mastodon parts, three pairs of bird humeri and breast portions which were identified by Dr. Alexander Wetmore, assistant secretary of the Smithsonian Institution, as being of the trumpeter swan (*Cygnus buccinator*).[4] The species is now said to be almost extinct, being found only in parts of northern Canada, although according to Audubon[5] and other early writers it was abundant in the Mississippi Valley a century ago. It is of no small interest to trace its residence here back to Pleistocene time.

A jaw and right femur have been identified as being of the giant beaver *(Castoroides ohioensis)*, the jaw having been identified by Mr. E. S. Riggs of the Field Museum and the femur by Professor L. A. Adams of the University of Illinois. The reports of workmen are obscure as to depth and other circumstances, but there is reason to believe that the specimens came from the upper marl layer.

In the peat layer above the marl, and consequently of later date, were found several horns and numerous bones of the Virginia deer, also skull and other parts of elk. Most of this material was submitted to Professor Adams who very kindly studied the collection and made identifications.

Buried in the black earth above the peat was a small skull identified as muskrat by Dr. S. H. McFarlene of Aurora College. Its condition suggests an age of perhaps a hundred years, thus bringing the sequence up to modern times. The black earth layer also produced the skeleton of a buffalo which does not show evidence of having been buried more than 30 to 50 years. The Custodian of Phillips Park is sure it could not be a captive buffalo which died in the park, his opinion being based on the skeleton having been found outside of the former park boundary. The finding of a buffalo skeleton, however, would not be out of harmony with the well known fact of their inhabiting this area in modern times.

A small cone found with the marl in the hollow end of one of the mastodon tusks has been identified by Dr. W. T. McLaughlin of Northwestern University as being of the species *Tusga candensis*, and throws some light on the vegetation of the time. Numerous sticks and logs of wood were found deep in the marl as well as in the upper layers. Some of these were twisted similar to cedar. The tapered end of one stick suggested that it may have been cut by a beaver.

The City of Aurora plans to keep the specimens. They are at present on display in a temporary museum at Phillips Park, and an attempt is being made to promote interest in a better housing for the material.

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[4] Wetmore, Alexander, Wilson Bulletin, XLVII:237 (Sept. 1935).
[5] Audubon, J. J., U. S. National Museum Bulletin 130, p. 300.

The Bottom Sediments of Southern Lake Michigan

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ABSTRACT[1]

Gravel and sand occur in a zone adjacent to the shore, silt occurs beyond the sand, and the deeper parts of the lake, generally below 250 feet, are covered with a fine clay. Areas of rock bottom are known in several places, all of which are within a few miles of the shore.

A detailed quantitative study of the sediments shows, however, that their size variations do not conform to the principles stated in geological texts. In the six principal series of samples, which were taken on lines perpendicular to the lake shore on both the eastern and western sides of the lake, it was found that the average size of the bottom material first decreased with increasing distance from shore and depth of water, then increased markedly. The coarsest bottom sediment, which was coarser than the beach sand, occurred about five miles offshore. Beyond the zone of coarse sand the average size of the bottom material rapidly dropped into the silt range, then slowly graded into the clay range. In most cases the sand-silt boundary occurred at the edge of a subaqueous terrace.

A detailed examination of the lake bottom in the vicinity of Chicago, where the sand-gravel zone is widest, showed that the gravel is a thin veneer occurring on undisturbed glacial till, and that it is a lag concentrate of the coarser constituents of the latter. The relations of the sand and gravel bottoms to topography are rather unusual. The gravel-veneered till is in the hollows, while sand forms the low ridges which are a characteristic feature of the area. Since these ridges are discontinuous and are not parallel with the shore, and occur in as much as 50 feet of water, their existence can best be ascribed to current action on the bottom.

[1] The full paper has been published in the *Journal of Sedimentary Petrology*, vol. 5, No. 2 (1935), pp. 57-80.

A New Medium for Teaching Geology in the Middle West

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The Museum of Science and Industry is located at the north end of Jackson Park, Chicago, and occupies the former Fine Arts Building of the 1893 Columbian Exposition. The exterior, originally of plaster, has been entirely refaced with limestone and granite; and through the benevolence of the late Julius Rosenwald, this building will stand as a memorial to the achievements in the arts, sciences, and industries of the past and present.

The exhibits will be arranged in ten departments or sequences, covering a wide scope of scientific and industrial thought. Important among these is the Department of Geology and the Mineral Industries which will occupy sixty-one thousand square feet of floor space. Fundamental laws and processes of geology will be shown to prepare the way for an understanding of geology's applications to engineering, mining, metallurgy, etc. A large portion of the building that is now open is occupied by exhibits of this sequence which will serve to illustrate the methods by which technical subjects are to be presented for non-technical consumption.

The outstanding exhibit of this group is the full-sized coal mine (described in the Museum's "The Story of Coal"). This mine represents a completely mechanized coal mine of the Illinois type. The visitors are taken on a tour, not as through a "museum exhibit", but as through a real coal mine where real mining machines are being used and where experienced miners may be seen at their regular duties. The visitors are lowered in a cage operated by an electric hoist and soon they are aboard the "man trip" on their way to the working face. Here the most up-to-date machinery is at work while the miners stand by to explain to the novice how coal is taken from nature and prepared for the market.

Other exhibits which are indicative of the future Geology and Mineral Industries Sequence are those depicting the story of oil and an operating model of a steel rolling mill. In the latter, small lead bars are actually rolled into long thin strips while the visitors are told how, on a larger scale, ingots are rolled out into strip steel.

The exhibits just described give but a brief conception of the magnitude of the entire sequence. Geology will be represented not only through its economic aspects, but the basic principles of geology likewise are to be portrayed in dynamic, pictorial, and three-dimensional exhibits. The origin and growth of our planet; the processes and phenomena of weathering, erosion, sedimentation; the theories pertaining to seismology, volcanism, and orogeny; the behavior of glaciers; the formation of caverns, and many other geologic features are to be treated in this popular fashion. Other exhibits showing geology's application will include important methods of metal mining and quarrying, to be shown in full size; diamond mining, metallurgy, ore dressing, metal working, and various machine arts will then complete the long story of the origin of nature's resources and the uses to which they have been put by man.

PAPERS IN MEDICINE AND PUBLIC HEALTH

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Of the seven papers on the program of the Medicine and Public Health Section, six were read in full and the following was read by title only:

"The Significance of Iodine in Thyroid Function," by George Curtis, M. D., Ohio State University, Columbus, Ohio.

The following two articles were not presented for publication:

"Significance of Occupational Diseases," by C. O. Sappington, M. D., Consulting Industrial Hygienist, Chicago.

"Efforts to Control Quality of Foods in the United States," by Fred W. Tanner, Head of the Department of Bacteriology, University of Illinois, Urbana.

Attendance at the meeting averaged about twenty-five.

Dr. Fred W. Tanner, University of Illinois, Urbana, was elected chairman of the section for 1935-36.

(Signed) B. F. WHITMORE, *Chairman*

Rickets—Its Cause, Effect, and Prevention

J. Howard Beard, M. D.
University of Illinois, Urbana, Illinois

Rickets or rachitis is a constitutional disease of childhood in which the bones become soft and flexible from delayed ossification, due to deficiency of calcium, phosphorus, vitamin D or sunshine, or possibly metabolic disturbances not at present thoroughly understood. The disease is characterized by bending and distortion of the bones under muscular action, by the formation of nodular enlargements on their ends and sides, by delayed closure of the fontanelles, pain in the muscles, sweating of the head, and degeneration of the liver and spleen.

There is often nervous affections, feverishness, convulsions, constipation, and anemia. Dentition may be retarded and irregular, the enamel defective in both the temporary and permanent sets of teeth, and an early tendency to decay be present. Adenoids, enlargement of the lymph glands of the neck, and hypertrophy of the tonsils are common. Inflammations of the respiratory and gastro-intestinal tracts are frequent occurrences.

Historical.—Rickets is in no sense a new disease. Soranus of Ephesus in the second century of the Christian Era observed that the legs of children often became bent at the thighs, and he raised the question as to "why so many Roman children were deformed." Galen, who lived between 130-210 A. D., described the condition with remarkable accuracy.

In 1582 Jerome Reusner of Basle published a thesis upon rachitis. Nearly one hundred years later (1645) Daniel Whistler gave a classic description of rickets, and in 1885 Palmer presented its pathology so clearly and thoroughly as to leave little to be added to it since.

In 1918 Mellanby stated that rickets was "a deficiency disease due to the absence of an accessory food factor," and Huldschinsky in Germany, a year later, demonstrated he could cure the disease by exposing children to artificial sunlight.

In 1924 Hess showed that vegetable fats, normally inactive against rickets, could be rendered antirachitic by exposure to ultra-violet rays and in living animals, vitamin D could be produced directly by the action of the same rays on a sterol under the skin. The whole problem of rickets is intimately associated with how far unfiltered sunlight rich in ultra-violet rays is permitted to act on the sterol of the food or on the sterol of the animal itself.

Prevalence.—Rickets is prevalent throughout the world. Years ago Palm observed the disease "was common where sunshine was scarce and rare where sunshine was abundant." It is less common in subtropical and tropical climates due, it is believed, to the increased efficiency of the sun in warmer climates and to the fact that its action is facilitated by lighter clothing and more bodily exposure.

Rachitis is especially frequent in northern temperate climates. It is more prevalent in Europe than America. In the United States it shows particular prevalence in Negro children and is quite common among those of Italians. It is widespread among the undernourished of our large cities, and its incidence tends to rise with the urbanization of the population.

Season apparently plays an important part in the occurrence of rickets because of its influence on the amount and the efficiency of sunlight. With the coming of colder weather the pollution of the air with soot further decreases the amount of ultra-violet light reaching the earth and renders conditions more favorable for the development of rickets. Symptoms of the disease are more frequent and more marked in winter than summer.

Rachitis usually occurs between the sixth and the eighteenth month. Its onset is insidious and the exact determination of the age at which it begins is usually impossible. It rarely begins after the age of three years and seldom before three months. It shows little if any relation to sex.

Cause.—Rickets seems to be due to a deficiency of a specific accessory food constituent called vitamin D, but our knowledge is incomplete as to how abnormal mineral metabolism is correlated with hyperplasia of cartilage. Antirachitic vitamin D is concerned with the regulation of the concentrations of phosphorus and calcium in the blood and with the calcification in bones and teeth.

Vitamin D was first noted by McCollom in 1923 and has been shown to be produced when foods or the human skin containing the unsaturated sterol, ergosterol, is subjected to ultra-violet rays. Crystalline products have been obtained which are highly antirachitic and to which have been given the formula $C_{27}H_{42}O$.

Rickets is less frequent and less severe in breast-fed than in artificially nourished children. The diet of artificially nourished children who develop rickets is frequently deficient in fat and rich in carbohydrates. The significance of this defect in diet is readily seen when it is noted that not withstanding Eskimo children live in darkness or decreased sunlight during the greater part of the year, rickets is relatively rare among them, due to the fact that their food consists of fats, oils, and fish livers.

Prevention

(1) *Prenatal*
- (a) The mother's food should contain an abundance of eggs, butter, and milk.
- (b) Her diet may be supplemented by viosterol, cod liver oil, vitamin D milk, or sunshine.

(2) *Breast Feeding*
- (a) Mothers should be provided with adequate amounts of Vitamin D, calcium, and phosphorus.
- (b) Sun baths or ultra-violet radiation of mothers are helpful.
- (c) Infants may be exposed to the sun or rays after thorough protection of their eyes.
- (d) If sunning or irradiation is not practical, vitamin D milk, cod liver oil, or viosterol, should be given.

(3) *Rules for Artificial Feeding*
- (a) Avoid excess of carbohydrates.
- (b) Keep fat content above three per cent by use of cream.
- (c) After first two months, use a half or a whole uncooked egg.
- (d) Give vitamin D. milk.
  1. "Metabolized"; 2. "Fortified"; 3. "Irradiated".
- (e) After first six months, feed more concentrated food (eggs, scraped beef, vegetable purees with butter, etc.).
- (f) Cod liver oil (for vitamin D),
- (g) Viosterol (for vitamin D), or
- (h) Halibut liver oil (for vitamin D).
- (i) Expose to sunlight if weather permits.
- (j) Ultra-violet radiation if sunshine is inadequate.

Studies in Milk Pasteurization

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Milk is pasteurized primarily to destroy the disease organisms which may be present. It also greatly reduces the number of other organisms and, therefore, not only makes the milk safe but also improves its keeping quality.

There has been much questioning about the effect of pasteurization of milk on its food value. The results of experimental work carried on with white rats indicate that pasteurization of cow's milk does not materially change its food value when the milk is fed liberally as the sole article of the diet. This might not be true of rat's milk and human's milk.

Ellis and Mitchell state "the pasteurization of milk slightly lowers the availability of its calcium for the growing rat, possible by destroying some unknown constituent of the milk that favors its utilization in the animal body." The basal ration they used was designed to be poor in calcium, but otherwise adequate for normal growth. This ration was provided daily with a milk supplement estimated to furnish from 5 to 7.5 m.g. of calcium per gram of gain made. It is difficult to conclude what effect this slight lowering of the intake of calcium would have on infant feeding. Attention should be called to the fact that cow's milk has twice the ash content contained in human milk.

The effect of pasteurization on the food value of cow's milk has been studied in this laboratory for several years. The method followed was to feed raw and pasteurized milk to white rats. The animals were given all the milk they would consume and it was the only article of diet. The mothers were fed milk only and the young were given cow's milk as soon as weaned. They were fed several times daily. The feeding vessels were cleaned daily and the milk supply was kept in a refrigerator to inhibit bacterial development.

An interesting fact about the animals used in this experiment is that most of them were the fourth generation of rats raised on milk as the main article of diet. However, it should be stated that the parents, grandparents and great grandparents of the animals used in the experiment were fed four Harris Yeast tablets per week and a few drops of cod liver oil daily, otherwise their diets consisted of milk only. The experimental rats did not receive yeast nor cod liver oil.

The average weight of the animals was 49 grams at the start of the experiment. Table 1 gives the average weights of the two groups of animals at the end of the experiment (5½ months) and also the average percentage of the calcium and phosphorus in the leg bones.

TABLE 1

Identification	Average weight of animal	Calcium	Phosphorus
	Grams	*Per cent**	*Per cent**
Group fed on pasteurized milk	185	34.36+	17.45+
Group fed on raw milk	184	34.25+	17.84+

* Percentages are based on dry weight of bones.

Incidentally, it should be mentioned that the reproduction in the rats fed milk as the only article of diet was greatly affected. Some females never had young and some litters of young were born dead. The size of the litters which did live varied from two to ten.

The results of another experiment are of more interest from a sanitary point of view than from a nutritional one. In the first experiment the milk used each day was milked from a healthy cow directly into a sterile container. Half of this milk was pasteurized in the laboratory at a temperature of 145° F. for 30 minutes, the rest was left raw. In the second experiment the milk was taken from a mixed lot of milk at the plant. Every two days two quarts of this milk were collected just before it entered the pasteurizer and two quarts of it were collected after pasteurization, the pasteurizing being carried on at 143-145° F. for 30 minutes. The milk was kept in the refrigerator.

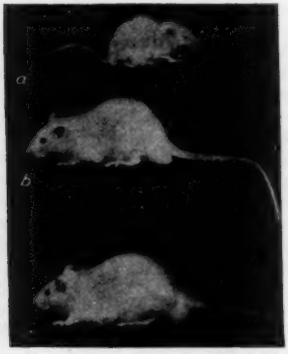

Fig. 1a. This rat was 113 days old and was fed raw milk for 90 days.

b. This rat was 113 days old and was fed pasteurized milk for 90 days.

c. This rat was 113 days old and was fed a mixed diet for 90 days. Previous to that it had been fed mother's milk, the same as the other rats shown here.

During the first month of the experiment the rats fed pasteurized milk and raw milk did equally well. After that time, however, it was noted first that the rats consuming raw milk were not consuming as much milk as they had been and second, it was noted that their coats roughened, and later it was noted that diarrhea had developed. Eventually the animals living on raw milk began to die. Each animal was autopsied. All the organs except the digestive system appeared normal. Both the stomach and intestines were greatly distended due to the presence of gas. A bacteriological study was not made and consequently no exact explanation of this sickness is known.

The animals that consumed the pasteurized milk were normal in growth and health. No doubt the causal agent for the death of the animals fed raw milk was in the raw milk and this was destroyed by pasteurization, since all the animals received the same care in all respects and the milk came from the same general supply.

The picture shows three animals, one from the group fed raw milk, one from the group fed pasteurized and one from a group that was given a mixed diet.

These nutritional studies were carried on for a period of three years, and during this time four experiments were conducted, each one lasting from four to six months. But the animals in the experiment just discussed were the only ones which had any serious illness.

Implications of Vibro-Tactile Phenomena

Robert H. Gault

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Director General of the American Institute for the Deaf-Blind

Certain sensory phenomena—vibrational and tactual—have been brought to light during the last decade in the course of experiments with what might be called "listening fingers," experiments in which spoken language is transmitted through a microphone and a specialized amplifier into a vibrating unit.[1] When one's fingers are resting upon this unit one discovers it vibrating along with the speaker's voice. In this situation, the deaf find an approach to the study of the spoken language.

The senses of touch and vibration (herein called the vibro-tactile senses) present many interesting parallels or points of similarity to the sense of hearing. Brought together, they suggest the hypothesis (it is now really better than a mere hypothesis) that when the various forms and characteristics of speech can be brought to the vibro-tactile organs with approximately as great a degree of distinctness as they reach the normal ear in the usual situation, men and women will be found able to make the vibro-tactile senses a substitute for the sense of hearing. The usefulness of these senses will then be enormously increased in relation also to the development and improvement of the speech of the deaf.

In our experimental laboratory situations, the vibro-tactile organs enable one to detect frequencies of vibration at least as high as 8,192 per second,[2] corresponding to the fifth octave above middle C on the piano. The lowest pitch that we have systematically observed corresponds to a rate of 64 vibrations per second, which is the second octave below middle C.

Amplification is required to obtain these results, and it must increase very sharply as we ascend the scale from the lower to the higher limit.[3] The upper limit quoted is considerably higher than is essential for receiving speech by ear.

In differentiating higher and lower pitches, our experiments have been confined to the first octave above middle C—400 vibrations per second.[4] Within this short range, at least, the vibro-tactile organs do as well as the normally hearing but musically untrained observer can do. The vibro-tactile organs also discriminate intensities of stimulation as accurately as the normal ear distinguishes one degree of loudness from another,[5] and by many thousands of observations we have demonstrated that they permit a high degree of accuracy in discovering changes in accent and emphasis and tempo of speech,[6] an accuracy approximating that attainable in hearing.

[1] Goodfellow and Krause: Apparatus for Receiving Speech Through the Sense of Touch. *Rev. of Sci. Instruments*, V, 1934, 44-46.

[2] Goodfellow: The Sensitivity of the Finger-tip to Vibrations at Various Frequency Levels. *Jour. Frank. Inst.*, Vol. 216, No. 3, 387-392.

[3] Goodfellow: *Op. cit.*, 392.

[4] Roberts: A Two-Dimensional Analysis of the Discrimination of Differences in the Frequency of Vibrations by Means of the Sense of Touch. Jour. Frank. Inst., Vol. 213, No. 3, 1932, 283-312.

[5] Knudsen: "Hearing" by the Sense of Touch. *Jour. Gen. Psychol.* I, 2, 1928.

[6] Ilieva: A Comparison of the Sense of Touch Alone and Vision Alone (Lip-reading) and of Both Working Together in Respect to the Detection of Changes in the Tempo of Speech. *Jour. Gen. Psychol.* X, 1934, 100-109.

Thompson: A Comparison of (*Supra*) in Respect to the Detection and Localization of Emphasized Words in Spoken Sentences. *Jour. Gen. Psychol.* XI, 1934, 160-172.

These observations enable us to foresee and to understand the next fact: the functioning of the vibro-tactile organs alone enables one, without great difficulty, to learn to identify each one of a long list of sentences by their total gross pattern. Thus when a lip-reader receives spoken language by means of the eye while at the same time he receives in his vibro-tactile organs the complicated patterns of vibrations that correspond to such language, he interprets more successfully than when he relies upon his eye alone. The increased accuracy amounts to more than 20 per cent.[1]

It is well known that those who have been totally deaf—even very hard of hearing—from birth or early childhood have extraordinary difficulty in mastering speech. At best they hear inadequately both their own and others' voices. Lip-reading cannot make them aware of our changes in accent, emphasis, tempo, rhythm, and pitch that are all involved together in our conventional pattern or melody of spoken language, but these characteristics can be brought to their awareness by bringing the patterns of spoken language to the vibro-tactile organs so they may be felt while the subject is observing the face of the speaker or following with his eye the printed or written page that his teacher is reading aloud. Having felt a sentence or paragraph pronounced in a certain pattern, the pupil becomes more likely to pronounce it in the same pattern, and if he feels it thus repeatedly and attentively we are reasonably assured that he will gradually, almost insensibly perhaps, adopt a pattern of speech that at least approximates that of his teacher.

The psychology of the situation is analogous to that in which the native citizen of Chicago returns from a season visiting in London or in Alabama exhibiting in his own speech some of the characteristics of that of the Londoner or the Alabamian, as the case may be. It is, in technical language, a case of having established certain *ear-vocal conditioned reactions*, and their establishment seems not to be utterly dependent upon an intention to acquire them. For the deaf, it is the establishment of *vibro-tactile-vocal conditioned* reactions.

An important step in this research has been the determination of the difference between the ear and the vibro-tactile organs in the finger in respect to their sensitivity to vibrational stimuli at various frequency levels as follows: 64, 128, 256, 512, 1024, 2048, 4096, and 8192 d. v. sec. The results are in terms of the number of pressure units that are essential for the detection of the stimuli by hearing and by feeling respectively. It is this type of work that is showing us what an amplifier must do if the vibro-tactile organs are to receive the essential pitches involved in speech in the same relations of intensity as they are normally received by the ear. We have now produced an apparatus—the Teletactor—that meets the requirements over a part of the necessary range. Its perfection and completion is an engineering problem.

This research, in its present stage, bristles with possibilities for the improved education and social amelioration of our sorely handicapped young people—the deaf and the doubly afflicted deaf-blind. The American Institute for the Deaf-Blind, incorporated in this State, has a program in which members of the medical profession are interested. The Institute is for the purpose of promoting such research as is aimed at finding the best possible means for educating and training the deaf-blind, the seeing deaf, the hearing blind, and at the protection of vision and hearing in the schools. I hope we may have the encouragement that will come from your being interested in us and in the work we are undertaking.

[1] Gault: On the Effect of Simultaneous Tactual-Visual Stimulation in Relation to the Interpretation of Speech. *Trans. Ill. State Acad. Sci.*, vol. 22, 1930, pp. 630, 653.

Results of Examining Pasteurized and Unpasteurized Milk for Brucella Abortus

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In studies previously reported from the Illinois Agricultural Experiment Station it was shown that Br. abortus in milk could be destroyed by carefully controlled pasteurization in the laboratory. The question then arose concerning the effectiveness of pasteurization as it is carried out in commercial plants. Through the cooperation of the Illinois State Department of Public Health and under the immediate supervision of Mr. S. V. Layson, Milk Sanitarian, samples of pasteurized and unpasteurized milk from many different sections of the state were submitted for examination.

The pasteurizers from which the milk samples were obtained for study varied in capacity from 100 to 800 gallons per hour and included coil vat, glass-lined, cylindrical, spray vat and continuous flow types.

Milk samples were collected from 68 different milk stations located in 28 counties. The largest group of samples examined from a single territory came from Sangamon County. The samples were collected immediately before and after pasteurization from the vats of pooled milk of one or more herds. The samples, therefore, represented composites of milk from many cows or herds. Samples were collected in sterile vials containing approximately one per cent boric acid as an inhibiting agent and forwarded to the laboratory in mailing containers. During 1933 and 1934 a total of 233 samples of milk were received for examination. Breakage in transit and spoilage incident to shipment, together with an intercurrent infection in the inoculated guinea pigs, made it impossible to complete the examination of 103 samples. A complete examination was made of guinea pigs injected with 130 samples, including 68 pasteurized and 62 unpasteurized samples. Upon arrival at the laboratory, the milk samples were placed in the ice-box until the cream had risen. Several loops full of cream were then smeared on gentian violet liver agar plates and the plates incubated in CO_2 at 37.5° C. By this technic Brucella abortus was not isolated from a single sample of milk. This is what might be expected due to the large number of contaminating organisms found in milk handled as these samples were. While boric acid is used as an inhibiting agent it is not intended to be a preservative and if it were the abortus organisms would therefore be destroyed. Two and a half cubic centimeters of the cream and the upper portion of the milk were injected into each of two guinea pigs.

Six weeks following injection, the guinea pigs were autopsied. Blood was collected from each pig for the agglutination test and a search was made for gross pathologic lesions of Br. abortus infection. The liver, spleen, lungs, lymph nodes, and testicles or ovaries were smeared on gentian violet

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liver agar plates and allowed to incubate at 37° C. for five days in jars containing ten per cent carbon dioxide.

None of the blood samples from the 136 guinea pigs injected with the 68 pasteurized milk samples reacted to the agglutination test. No macroscopic lesions suggestive of Brucella infection were found and the organism was not isolated from a single pig. The blood from 45 of the 124 guinea pigs inoculated with the 62 unpasteurized milk samples gave a positive agglutination reaction in dilutions of 1 to 100 or higher and one gave a reaction in a dilution of 1 to 50. Pigs showing positive titres in 1 to 100 or more showed gross lesions in the spleens and livers in 73.3 per cent of the cases and 77.7 per cent yielded positive cultures of Brucella.

Brucella was isolated from guinea pigs injected with 31 or 50 per cent of the 62 unpasteurized pooled milk samples. All of the isolated Brucella strains proved to be of the bovine type when propogated on differential diagnostic media described by Huddleson.

The detection of abortus in samples from pooled milk by either direct culture or by the agglutination test are not as reliable as guinea pig inoculation. Direct cultures, even on selective media, are unsatisfactory because of the heavy contamination. The agglutination test is equally inefficient on pooled samples due to the factor of great dilution. Both direct culture and the agglutination test, however, are efficient when samples are drawn from individual quarters of the cow.

The percentage of Brucella infection encountered in the samples examined is obviously higher than the incidence of the disease in Illinois herds, and it is assumed that the pooling of milk from several cattle or several small herds which comprise the composite samples accounts for this variation. Obviously if milk from Bang's disease free herds is mixed with milk from infected herds it naturally follows that the organism may be present in the composite milk sample.

The following conclusions may be drawn from the data here presented: Brucella abortus is not uncommon in unpasteurized pooled milk from dairy cattle in Illinois and that pasteurization of raw milk as employed in Illinois milk depots from which samples were taken destroys the Brucella organisms present.

Summary.—(1) Brucella abortus was isolated by guinea pig inoculation from 50 per cent of 62 raw milk samples collected at milk depots in 28 widely distributed counties of Illinois.

(2) Pasteurization as employed in milk depots from which samples were collected is effective in destroying Br. abortus in milk.

(3) Brucella abortus, bovine type, is apparently the most prevalent in milk of Illinois.

PAPERS IN PHYSICS

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

Of the sixteen papers on the Physics program, fourteen were presented at the section meeting. The following was read by title only:

"Some Topics in Physiological Mechanics," by I. M. Freeman.

The following papers were read at the meeting but were not presented for publication:

"The Concept of Oscillations in Present Physical Theory," by Jacob Kunz, University of Illinois.

"Atomic Disintegration or Modern Alchemy," by A. J. Dempster, University of Chicago.

Attendance at the meeting of the Physics Section averaged seventy-five, maximum attendance was eighty-three.

Otis B. Young, Southern Illinois Normal University, Carbondale, was elected chairman of the section for the year 1935-36.

(Signed) LESTER I. BOCKSTAHLER, *Chairman*

A Convenient Chart for Correcting Barometer Readings

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You will all, no doubt, recall sometime or other when you have been doing precision work in the laboratory and have had to stop to perform the irritating task of computing the exact boiling point of water.

Furthermore you probably remember such formulas as:

$$h_o = h_t \{1-(d-\beta t) = H_r$$

$$H_o = 760 + 1.9456 \cos 2\lambda + .00004547\ h$$

These corrections cannot be done accurately with a slide rule, and the tables in the chemistry and physics handbook are incomplete and involve subtractions and additions besides.

On the other hand, all of the recent editions of such handbooks include very accurate and complete data on the vapor pressure of water. These readings for barometeric pressure, however, are sea level measurements taken on the 45° latitude with the scale and mercury at 0° Centrigrade. It is necessary for us first of all, to determine what reading in the handbook (standard) will correspond to the pressure at our station. This can be done very simply by the graphic method.

We shall begin by plotting the standard pressures of the handbook against the boiling point of water, with the standard pressures on the X axis and the boiling point on the Y axis—but at the right of the chart.

Now, letting H_o represent the standard pressure at a given locality we have the formula $H_o = 760 + 1.9456 \cos 2\lambda + .00004547h$ where λ is the degree of latitude and h is the elevation in feet.

In almost every locality there is a government bench-mark giving the altitude of the station. If Hr represents the barometeric pressure on a given day.

$$\frac{H_r}{H_o} - 760 = \lambda_t \text{ (reading in the tables)}$$

This is a straight-line function whose slope is $H_o/760$. Using the same figures for standard pressures employed before along the X axis, let H_r be on the Y axis but to the left of the chart.

Now this H_r is the true barometric pressure as taken from a barometer at 0° Centigrade. But recalling the formula stated above, $h_o = h_t \{1-(d-\beta)t\}$ we see that for a given value of t this is a straight-line function. But this ho equals Hr. Now plot a separate curve for various values of t. This time let the values on the X axis (used before as standard readings) represent the actual barometer reading. It is convenient to draw curves for every two degrees from 16 to 28, depending upon the mean temperature of the room in which the barometer is located.

We now have three charts: one to correct the barometer for temperature, another to transfer the reading to the corresponding reading for sea level at the 45° latitude, and still another to give the boiling point of water.

The process is now very simple. It is only necessary to read the barometer and to record the temperature of the room. Locate this barometer reading on the X axis; find the intersection of the ordinate of this point with the curve for the room temperature; follow the abscissa of this point to the curve correcting for altitude and latitude, then follow the ordinate of this point to the boiling point curve and the abscissa of this point (read from the right) gives the true boiling point of water.

Once completed, this is a very convenient chart for correcting all of these errors with a minimum of time lost. The chart at Wesleyan has a maximum error of .001°.

On Growing Bismuth Single Crystals

J. A. Boyajian

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In a single crystal, the angles between the crystallographic axis and the axis of the crystalline rod are the same from one end to the other. Single crystals of a metal are generally grown from the melt by allowing the metal to cool very slowly. However, if one wishes to produce a single crystal of a metal with a predetermined orientation, the rod which is to be crystallized must be inoculated with a seed-crystal. When this is done in the proper manner, the orientation of the seed-crystal is carried on throughout the length of the bar as it slowly crystallizes from its molten state.

Bismuth is one of the metals which crystallizes most easily. This is probably due to its low melting point (271°C) and because it has fewer crystallization centers than most metals. Bismuth crystallizes in the rhombohedral division of the hexagonal system which approaches very nearly a cube.

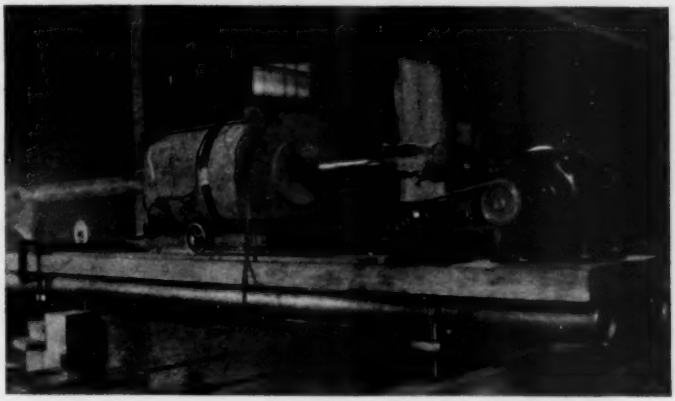

Fig. 1.—Movable furnace used in growing bismuth single crystals.

The apparatus used to grow single crystals of bismuth is easily constructed, and quite simple to operate. It consists of a movable furnace resting on tracks fastened to a very rugged platform (Fig. 1). Motion is given to this furnace by means of a weight fastened to a chain which runs over a pulley, and the other end of the chain is fastened to the furnace. The velocity of the furnace is governed by varying the speed of a DC motor, which runs a set of gear boxes with a ratio of 90,000 to 1. A sprocket chain is fastened to the other end of the furnace and then runs over a driving gear fastened to the shaft of the gear box. Thus as the motor pays out chain, the weight at the other end pulls the furnace along the track at a uniform rate.

The pyrex glass tube used for the growing chamber passes through the center of the furnace, and is supported at either end by means of clamps. The stands holding these clamps rest upon a concrete pier which is independent of the support for the rest of the equipment. This arrangement allows the crystals to be grown free from vibrations set up by the motor, or from other sources. This glass tube is evacuated to enable the crystals to be grown free from oxide coatings.

The production of crystals of the desired shape and size required two types of moulds: a casting mould and a growing or seeding mould. These moulds were made of Acheson graphite because it can be machined easily, and does not react with the metal. The casting mould has a cavity in which the bismuth is placed, and a trough also cut in to give the metal its proper form when the molten metal is poured from the cavity. A cover must be clamped tightly to the casting mould to aid in pouring and to keep the metal from running out. The growing mould must have the same internal dimensions for its trough as the casting mould. One end of the growing mould is cut down to provide a ledge for the seed which may be rotated about the vertical axis to give the desired angle of orientation after it is welded to the polycrystalline bar. The apparatus is, in some respects, similar to that used by M. F. Hasler.[1]

The polycrystalline bars were cast by withdrawing the pyrex tube containing the mould with the molten bismuth in its cavity, and tilting it to pour the metal into the trough of the mould to give the casting the desired shape. These polycrystalline bars were then seeded in the growing mould by allowing the whole bar and half the seed to become melted. At this point, the motion of the furnace is started and the metal is allowed to crystallize by cooling slowly. An important factor influencing crystal growth is that a proper temperature gradient must exist at the zone of crystallization. This was found to be 20° per cm for bismuth.

[1] M. F. Hasler, Rev. Sci. Inst. 4, 656 (1933).

The Atomic Beam as a Spectroscopic Source

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The first spectroscopic source was sunlight, a continuous radiation with dark lines due to absorption in the sun's atmosphere. As soon as this was understood spectroscopists went to work with flames, arcs, sparks and various discharge tubes, identifying and cataloguing the spectra of the various elements. Next these spectra were analyzed and ascribed to transition of the atom from one energy level to another. As apparatus improved many lines and therefore energy levels were seen to consist of several components, readily explained by the interaction of the electron spins with the azimuthal moments. The twin yellow lines of sodium are a familiar example of such multiplicity.

Hyperfine structure, a still further splitting, can be explained by consideration of the nucleus. Each isotope has its own energy levels and spectrum differing only minutely. Furthermore the isotopes of odd atomic weight have a nuclear moment, which interacts with the resultant of spin and azimuthal moment to give the hyperfine splitting of energy levels and spectral lines.

Unfortunately spectral lines are not perfectly sharp. Doppler broadening, due to the random motion of the atoms, is usually serious. The breadth at half intensity is given by the relation

$$\Delta\nu = (1.67\nu_0/C)\sqrt{2RT/M}.$$

This must be reduced to a minimum to observe hyperfine structure. If we reduce the wave number ν_0 we are driven towards the ultra-violet and X-rays. An increase of M, the atomic weight, limits us to the heavier elements. The temperature T may be lowered with liquid air but this is often insufficient.

An atomic beam is the solution. A stream of radiating particles moving at right angles to the observer would have no Doppler effect. An atomic beam can easily be produced in a vacuum with an oven and two collimating slits but such a beam is invisible and must be excited.

Felix Esclangon[1] sent an atomic beam into an atmosphere of argon excited with a high frequency electrodeless discharge. The beam showed up brightly against the fainter illumination of the background. The spectrum was not limited to the resonance lines.

Under the direction of Dr. Russell Fisher I have been developing such a source for use with the lighter elements. Each of the sodium D lines is easily resolved into two components due to the splitting of the lower level. Jackson and Kuhn,[2] in absorption with an atomic beam, found the separations of the D_1 and D_2 doublets to be 0.061 cm^{-1} and 0.056 cm^{-1} respectively. This difference indicates a splitting of the upper levels. Since the nuclear mechanical moment is 3/2, D_1 should actually have four components, D_2 six. We are at present endeavoring to resolve some of these. The breadth of our lines is but 0.009 cm^{-1}; that of Jackson's and others' about three times as great.

[1] F. Esclangon, Annales de Physique, Series 11, Vol. 1, 401 (1934).
[2] D. A. Jackson and H. Kuhn, Proc. Roy. Soc., v. 148, 335 (1935).

An interesting field for study is the collision of the argon with the sodium atom. Some of the argon is ionized; a larger portion is metastable, the possessor of excitation energy which it can release only in collision; all of it is in random motion. Upon collision the sodium loses an electron and there is an exchange of momentum. The sodium lines must be broadened by the resulting motion but the amount is evidently small. (N. B. Subsequent work has shown that the excitation of the sodium is almost wholly due to impact of the high speed electrons formed when the argon is ionized.)

Our apparatus consists of a 52 mm. Pyrex tube 50 cm. long; at the top is a liquid-air-cooled target. A ground joint supports a nickle crucible with its heating wires and thermocouple. The lower "slit" is an 0.8 mm. diameter hole in the crucible cover. A tight fitting aluminium spinning is drilled 1.5 mm. to form an upper slit 2.5 cm. above the other. Argon is introduced just above the upper slit and pumped off with a mercury pump from the lower chamber. The pressure is adjusted to the lowest value that will sustain a discharge. High pressures visibly broaden and shorten the beam and hyperfine structure fades out of the interferometer. The pressure between slits is perhaps one third of that above, depending upon the fit of the aluminium spinning. This reduces undesired collisions and increases the mean free path of the sodium which either flies through the upper slit or hits the aluminium either to stay or to fly off again to condense finally on the water cooled walls of the tube. The intensity of the discharge is in direct proportion to the amount of sodium in it and to the vapor pressure in the oven. The useful value is limited by a reduction in the mean free path of the sodium issuing from the crucible. The effect is as if the sodium were issuing from a source midway between slits and the beam is consequently broadened. We have found 350° C a satisfactory temperature.

Argon is stored in a 300 cc tube. Its pressure may be controlled by displacement with mercury. The argon leaks through a capillary into the discharge tube. Contamination by mercury or stopcock grease is avoided by a liquid air trap. This is important in subduing the background and emphasizing the atomic beam.

The oscillator is push pull, tuned plate, tuned grid, using two No. 852 de Forest, 100 watt tubes at 30 megacycles. The inductance is four turns 5/16-inch copper tube spaced ¼-inch and 4 inches diameter.

The optical system comprises a Fabry Perot etalon with 11 cm. spacer and a spectrograph. Admitting a probable resolution of one tenth of an order we have a resolving power of 37 million or an ability to distinguish two lines separated 0.0045 cm^{-1}. Ruling the interferometer as described by Mr. Machler[3] in the next paper greatly increases the brightness of the pattern. An interferometer with such a large spacer can best be adjusted by the light of the atomic beam itself. Rings can be seen with a mercury arc for about thirty seconds; then the vapor gets hot and the rings merge.

[3] R. Machler and R. Fisher, Jour. Opt. Soc. Am. Sept. (1935).

An Appraisal of the Definitive System of Units

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HISTORICAL BACKGROUND

For the sake of perspective may I first call your attention to a few facts which are quite as well known to the members of this section as to me? Among them I shall mention first the marked difference between a haphazard set of units, such as a mile of 1,760 yards, a yard of 3 feet, a foot of 12 inches, a gallon of 231 cubic inches, another of 277¼ cubic inches, an area of one square mile containing 640 acres, etc., and, on the other hand, a coherent system of units such as that introduced by the French people about 1795, in which length, area, volume, mass, and force are all tied together in a natural, simple and decimal manner. The distinct economy of thought secured by a system of simply related units is too patent to call for discussion.

Secondly, I remind you of the long search which was made to find a standard of length and a standard of mass which should be natural and universal and hence capable of being determined, or tested, by any independent and accurate observer, just as the second or mean-solar-day now is. The two principal competitors for the first of these standards were the length of the seconds-pendulum and a definite fraction of the earth's meridian. The decision was made on the 10th of December, 1799, in favor of one ten-millionth of the earth's quadrant; and, on the same day, the kilogram was defined as the mass of a litre of water.

Thirdly, I recall that when the International Commission on Weights and Measures met in Paris in 1872, it completely abandoned the idea of natural standards and arbitrarily defined the metre as the distance between two rulings on a certain bar of metal in Paris, and the standard kilogram was, in like manner, arbitrarily fixed as the mass of a certain piece of platinum-iridium alloy in Paris.

Accordingly, at the present moment, two of the three fundamental mechanical units are entirely arbitrary while the remaining one, the *second*, *is* eminently natural. The prospect, however, is that the standard of length may shortly become a wavelength of light and that, if the irregularities in the rotation period of the earth, now suspected, are established, our standard of time may become the vibration period of an arbitrarily chosen quartz crystal; in which event, the *metre* and the *second* would just interchange their arbitrary and natural qualities.

EARLY ELECTRICAL AND MAGNETIC UNITS

Nothing can be more patent than the fact that electrical units are needed the moment that electrical measurements are begun. The quantitative work in electrostatics by Cavendish, Coulomb, and their contemporaries was done with units of their own individual choice. They used their own bodies, indeed, as voltmeters.

As the number of investigators increased and as new phenomena were discovered, the difficulty of accurate description and of comprehension increased. From the invention of the voltaic cell, in 1800, to the discovery of electromagnetism in 1820, there was an urgent demand for a current-meter, but practically no supply.

The eleven years between 1820 and 1831 were, however, so rich in discovery that they practically created a crisis, which was first met by Gauss

TABLE 1

1820. 21 July. Oersted's Discovery.
1820. Schweigger's "Multiplier".
1820. Biot and Savart's Law. $H = Kl/r$.
1821. Seebeck's discovery of thermo-electricity.
1822. Fourier's *Theorie Analytique.*
1823. Barlow's "Stellate wheel".
1825. Sturgeon's Electromagnet.
1826. Ampere's *Theo. Math. Phenom. Electrodynamique*
1828. Ohm's Law.
1831. Faraday's discovery of Induced currents.

in 1833. In this year he reported his two experiments upon the behavior of a magnet in the earth's field. One of these experiments, as you know, gave him the ratio of the magnetic moment of the magnet to the earth's field; the other gave him the product of these two quantities, M. and H. By elimination between these two equations he obtained for the first time an expression for the intensity of the earth's magnetic field in terms of mechanical units.

By use of the tangent galvanometer, invented by Pouillet in 1837, it became immediately possible to measure electric currents in absolute units. Magnetic flux was, from now on, easily expressible as a surface-integral of a magnetic field; and hence (through Neumann's description of Faraday's discovery, $E = -\frac{N}{t}$, electromotive forces were determined in absolute measure. Units were now needed for all three of the quantities appearing in Ohm's law, in addition to those employed in magnetic work.

EXTENSION OF OHM'S LAW

In the meantime, however, the original expressions of Ohm's law (which was, indeed, only an adaptation of Fourier's law of heat-conduction enunciated in 1822) had been undergoing rapid expansion so as to include circuits involving both capacitance and inductance, distributed as well as local. This development will be sufficiently clear from Table 2 without going into details as to nomenclature.

TABLE 2

Ohm's Law

$$Ri = E$$

$$L\frac{\delta i}{\delta t} + Ri = E$$

$$L\frac{\delta i}{\delta t} + Ri + \frac{Q}{C} = E$$

$$L\frac{\delta^2 Q}{\delta t^2} + R\frac{\delta Q}{\delta t} + \frac{Q}{C} = E \sin pt$$

$$C_1 L_1 \frac{\delta^2 i}{\delta t^2} + C_1 R_1 \frac{\delta i}{\delta t} = \frac{\delta^2 i}{\delta x^2}$$

By the time that the first Atlantic cable was laid, certain arbitrary units had come into vogue, such as Jacobi's resistance, Daniell's cell for E.M.F. and Siemen's mercury unit for resistance.

Latimer Clark and his brother and Sir Charles Bright became interested in the cause of numerous failures in marine cables and through these men the matter was first brought to the attention of the British Association for the Advancement of Science in 1861.

CREATION OF THE INTERNATIONAL SYSTEM

In 1863 Clerk Maxwell and Fleeming Jenkin reported to the British Association what is essentially our present system of *electrostatic*, *electromagnetic*, and *practical* systems of units. Through the fifty years following this report, this triple system has been extended and modified in nomenclature, in precision and in standardization, through the efforts of many individuals, cooperating institutions, and international conferences, culminating, one might almost say, in the "international system" defined by the London conference of 1908.

Table 3 illustrates, very roughly indeed, the steps of this development.

TABLE 3

1863. E.S. and E.M. systems reported to British Association by Maxwell and Jenkin.
1873. *Ohm* and *Volt* adopted in England at Bradford Mtg. British Association.
1881. First Elec. Congress (Paris) adopts *Ohm*, *Volt*, *Ampere*, *Farad* & *Coulomb*.
1889. Second Elec. Congress (Paris) adopts *Joule* and *Watt*.
1891. Third Elec. Cong. (Frankfort) recommends *Gauss* and *Weber* for H and B.
1893. Fourth Elec. Cong. (Chicago) adopts *Henry*, as unit of inductance.
1900. Fifth Elec. Cong. (Paris) recommends *Gauss* and *Maxwell* for H and ϕ.
1908. "International" units adopted at London.

The fundamental facts here are the adoption of the *ohm* as being the nearest practicable representative of the Siemen's mercury unit; the *volt* representing as nearly as possible the E.M.F. of the Daniell cell; and the watt as the only unit of power consistent with the ampere and the volt. The London conference, in 1908, adopted values for the *ohm* and *ampere* which were to a slight extent arbitrary, and thus made them play the rôle of "fundamental" units for other electrical and magnetic quantities. They are now known as "international" units.

When, as an undergraduate at Princeton, I first met these two great systems of units, electrostatic and electromagnetic, they impressed me as so complete and perfect that I felt sure that Moses had brought them down out of the mountain along with the ten commandments. But I was soon disillusioned; for within a year or two, I learned that the currents we had been measuring in the laboratory in terms of *webers* were now measured in terms of *amperes*: also that such eminent authorities as Clausins, Helmholtz, Rucker and others were differing among themselves as to the "dimensions" of the magnetic units.

Table 4 shows the principal adoptions of recent years, in the way of practical units. I refer to those made by the International Electrical Commission meeting at Oslo in 1930.

TABLE 4

C. G. S. Magnetic Units

Quantity	Symbol	Name	Date
1. Magnetomotive force	F	Gilbert	1930
2. Magnetising force	H	Oersted	1930
3. Magnetic flux	ϕ	Maxwell	1900 & 1930
4. Magnetic flux density	B	Gauss	1930

So much for the evolution of the three earliest and most widely used of the various systems now in practice.

THE SCIENTIFIC BASES OF SOME OF THESE SYSTEMS

For the sake of clearness in what is to follow, it will be well for a moment to consider the conventions—that is, the postulates and definitions—which underlie some five or six of the systems which have received wide acceptance.

(1) **Electrostatic C. G. S. system.**—The Committee of the British Association, in 1862, created this system by adopting, as their four fundamental units, the following quantities; the *centimeter*, the *gram*, the *second*, and the *specific inductive capacity of space*. Then followed the definition of *electrical quantity* from Coulomb's law, *current* from $i = Q/t$, etc., in the well known manner.

(2) **Electromagnetic system.**—Here the four fundamental units are different from the preceding, being the *centimeter*, the *gram*, the *second*, and the *magnetic permeability of space*. Again Coulomb's law is employed; this time to define the unit *magnetic pole*, and hence the unit of *current* by Biot and Savart's law, or by its equivalent.

(3) **Practical or Q. E. S. System.**—This system, used "everywhere, always, and by everyone," is explained by Maxwell (in Section 629 of his great treatise on *Electricity and Magnatism*), as based upon the following four fundamental units; 10^9 *centimeters*, 10^{-11} *gram*, the *second*, and the *magnetic permeability of space*. These four fundamental units are identical, *in kind*, with those of the electromagnetic system, but their size is so chosen that they yield at once the *ohm*, the *ampere*, and the other six practical units. Thus, for example, the unit magnet pole, m, is defined by the following equation where r is the distance separating two equal poles and F is the force exerted by one on the other.

$$m = r\sqrt{F} = 10^9\sqrt{F} = 10^9\frac{\sqrt{10^{-11}\times 10^9}}{1} = 10^9 \times 10^{-1} = 10^8 \text{ c. g. s. units.}$$

In like manner, the unit of magnetic field, H, is defined as follows:

$$H = F/m = 10^{-2}/10^8 = 10^{-10} \text{ c. g. s. units.}$$

$$\text{Unit magnetic induction} = H \times \text{unit area} = 10^{-10} \times 10^{18} = 10^8 \text{ c. g. s. units.}$$

$$\text{Hence unit E. M. F.} = -\frac{\delta N}{\delta t} = \frac{10^8}{1} = 10^8 \text{ c. g. s. units, which is one } \textit{volt}.$$

(4) **Heaviside–Lorentz System.**—Since the Gaussian system is identical with that of Heaviside and Lorentz, save for a shift of 4π from one equation to another, we shall consider only the latter. Heaviside starts from the two following expressions for the inverse square law:

$$F = \frac{qq'}{4\pi r^2} \text{ and } F = \frac{mm'}{4\pi r^2}$$

This rationalizes certain equations and makes the total flux from unit pole equal to unity.

Since ϵ_0 and μ_0 are each taken as unit, in their own fields, the dimensions of any quantity are the same in the electrostatic as in the electro-

magnetic system; but a constant, c, the ratio of the sizes of the units in these two systems, is introduced whenever an electric and a magnetic quantity appear in the same equation.

(5) **International System.**—Here the four fundamental units are the *centimeter*, the *second*, the *ohm*, and the *ampere*, as indicated in Table No. 5. The dimensions of the electrical units are greatly simplified in this system, but those in the field of dynamics are correspondingly complex. The scheme is of special interest to those laboratories which are charged with the preservation and testing of electrical standards.

TABLE 5

The International System

	Quantity	Symbol	Unit	Defining Equation
1.	Length	L	Centimeter	} Fundamental
2.	Time	T	Second	
3.	Resistance	R	Ohm	
4.	Current	I	Ampere	
5.	E. M. F.	E	Volt	$E = RI$
6.	Quan. Elec.	Q	Coulomb	$Q = Idt.$
7.	Capacity	C	Farad	$C = Q/E$
8.	Dielec. Const.			$K = \frac{4\pi LC}{S}$
9.	Elec. field		Volt/cm	$E = \frac{dE}{dL}$
10.	Self inductance		Henry	$L = E/\frac{dI}{dt}$
	etc.	etc.	etc.	etc.

(6) **Definitive or M. K. S. Ω. System.**—Thirty-one years ago this coming summer, an International Congress of Arts and Science, and also an International Congress of Electricians, met at the World's Fair in St. Louis. The proceedings of the first of these congresses fill eight large octavo volumes and constitute a cross-section of human knowledge in the year of grace 1904. The proceedings of the electrical congress occupy three octavo volumes, which contain little on the subject of electrical standards or units. Two of these latter communications, however, made a distinct impression; one is by Dr. Frank A. Wolff of our own Bureau of Standards, who points out a number of really serious defects in the definitions then employed in our system of electrical and magnetic units. The other paper is one by Professor G. Giorgi of the University of Rome, presented, in his absence, by the Italian Delegate, Mr. Ascoli.

Professor Giorgi's proposal is to embrace in a single, coherent, consistant and comprehensive system all of our present dynamical, electrical and magnetic units, in such a way as not to disturb any one of the eight practical units upon which the five previous international conferences have agreed. A simplification so tremendous as this is not to be expected without some cost. My sole purpose in addressing you this afternoon is to present both sides of Giorgi's proposition in an unbiased way. During these thirty-one intervening years, this plan from Italy has been impressing itself upon electrical men. It has come up for discussion in the *London Electrician*, in the *Encyclopedia Britannica*, in the *Bulletin* of the Bureau of Standards, in the American Physical Society, in the A. I. E. E., and in 1933 was the prin-

cipal topic discussed in the American Section of the International Union of Pure and Applied Physics, meeting in Chicago.

A few words now concerning the system itself; and then finally a few more concerning its merits and demerits.

Like the five preceding systems, it is based upon four fundamental units, namely, the *meter*, the *kilogram*, the *second*, and the international *ohm*. The "international ohm", it will be recalled is the resistance of a thread of mercury, of prescribed mass, having a length of 106.3 mm, a value which has long been known to be about 1/20 of one per cent larger than the c. g. s. absolute ohm.

The easiest approach to the "definitive" system is perhaps to follow through the logical sequence of the derived units for dynamics, as well as for electricity, in the manner employed by Dr. George A. Campbell of the American Telegraph and Telephone Co.; for he is the clearest and ablest expositor which the system has found this side the Atlantic.

In Table 6, each derived unit is clearly defined in terms of those which precede.

TABLE 6

The Definitive System of Dynamical, Electric and Magnetic Units

	Quantity	Defining Equation	Name
1.	Length	L	Meter
2.	Time	T	Second
3.	Mass	M	Kilogram
4.	Resistance	R	Ohm
5.	Area	$S = L_a L_a$	Square meter
6.	Volume	$V = SL$	Stere
7.	Density	$d = MV^{-1}$	Kg/stere
8.	Speed	$v = LT^{-1}$	Meter/second
9.	Acceleration	$a = vT^{-1}$	Meter/second^2
10.	Force	$F = Ma$	————————?
11.	Energy	$W = FL$	Joule
12.	Power	$P = WT^{-1}$	Watt
13.	Torque	$t = FxL$	————————?
14.	Elec. current	$I = \sqrt{PR^{-1}}$	Ampere
15.	Elec. quantity	$Q = IT$	Coulomb
16.	Elec. potential	$E = WQ^{-1}$	Volt
17.	Elec. field	$E = EL^{-1}$	Volt/meter
18.	Elec. capacity	$C = QE^{-1}$	Farad
19.	Elec. capacitivity	$\kappa = CL^{-1}$	Farad/meter
20.	Elec. resistivity	$\rho = RL$	Meter—ohm
21.	Elec. displacement	$D = \kappa E$	Coulomb/meter^2
22.	Elec. Inductance	$L = RT$	Henry
23.	Magneto motive force	$F' = NI$	Ampere-turns
24.	Magnetic field	$H = FL^{-1}$	Ampere-turns/meter
25.	Magnetic pole	$m = FH^{-1}$	Volt-second/turn
26.	Magnetic moment	$m = mL$	(Volt-second turn) meter
27.	Magnetic flux	$\phi = ETN^{-1}$	Volt-second/turn
28.	Magnetic reluctance	$R = \phi^{-1}F'$	Henry^{-1}–turn^2
29.	Magnetic permeance	$P = \phi F'^{-1}$	Henry/turn^2
30.	Permeability	$\nu = P'L^{-1}$	(Henry/turn^2)/meter
31.	Mag Flux den.	$B = \phi S^{-1}$	(Volt-second/turn) per square meter

In the complete system there are, of course, many more quantities than the 31 here listed, but these include the most important ones and are sufficient to illustrate the whole.

THE DEBITS AND CREDITS OF THE DEFINITIVE SYSTEM

Among the features of this comprehensive system which may give rise to unfavorable comment are:

(1) The fact that the numerical value of any density determined in the c. g. s. system would be multiplied by one thousand.

(2) The fact that the new unit of force, which would do one *Joule* of work when exerted through one *meter*, is very large compared with the dyne, and would call for a new name.

(3) The fact that the dielectric constant of space, κ_0 would no longer have the value unity, but 8.86×10^{-12} farads per meter; and, in a similar manner, $\nu_0 = 1.257 \times 10^{-6}$ henries per turn^2 per meter.

(4) The lack of symmetry in Maxwell's field equations.

On the other side of the account, one has a large number of advantages, which have already been set forth by Dr. George A. Campbell and Professor Giorgi. Among these, I may mention the following:

(1) Complete uniformity, in both units and equations, in the shop, market place, test room, laboratory, and study.

(2) Students would have to learn only one simple, comprehensive, coherent, and universal system of units.

(3) All fundamental units would have material standards, with every possible provision for ensuring continued preservation of constant values.

(4) The old wall of partition between electric and magnetic quantities which existed up to the year 1820 and which has been out of place ever since Oersted's great discovery, would disappear.

(5) All eight of the named practical units would be included except for very slight adjustments, using the familiar defining equations.

(6) The calibration of ammeters, voltmeters, wattmeters, and resistance coils would remain unchanged since the adjustments required are too small to affect even the precision instruments of commerce.

(7) The equations of the system are effectually rationalized, due to the choice of the ampere-turn as the unit of magnetomotive force.

Other advantages might be mentioned; but these are ample to emphasize the simplicity and clarity of the proposed system.

Coming generations of students, engineers, and men of science will realize the benefits conferred by a single, universal system of units, backed up by a single sequence of equations, and will, it is my belief, thank the generation that shall have the courage to introduce it.

Ripple Tank Experiments

S. E. Boomer

Southern Illinois State Normal University, Carbondale, Illinois

Visual education has been growing rapidly in elementary and secondary schools with gratifying results as shown by scientifically conducted tests. It is quite as effective for college students. Teachers of physics have been pioneers in visual education for they have long used demonstration experiments, but when we have performed the same simple experiments before many classes we are likely to discard them, forgetting that to our students they are new and effective.

Waves fill incomparably more space than matter (and possibly matter itself is a wave phenomenon) and transmits vastly more energy than all other methods combined. Most of these we cannot see but the ripple tank helps to illustrate many wave phenomena, simple demonstrations of which are helpful to college students.

A series of closely spaced ¾-inch holes in a board illustrates Huygens' Principle. A sharp edge made by the intersection of a plane and a curved surface shows diffraction. Grating spaces should be about 2½ or 3 inches long, separated by the same distances. To show the advantage of a parabolic reflector for head lights and a spherical reflector for lighting a room, cut a parabola and the arc of a circle from boards or shape them from sheet metal. Slight shifts in the disturabnce are instructive. Cut out an ellipse and show that the sum of the distances from a point on the ellipse to the foci is constant. With rubber tube, form shapes of various halls and auditoriums. Reverberation can be shown, good and bad areas identified. If the board used to show Huygens' Principle be placed near one wall of tank, rough surfaces are shown to be poor reflectors.

Outside stone steps leading to the second floor of our main building forms the best eschelon grating I have observed. Blocks cut from a 2″ x 4″ built into stairway lying on its side show successive reflections of a single impulse which explains the high pitched tone.

Recently Mr. Lowell Davis gave a special report on echoes in my class in sound. To illustrate the whispering gallery under the dome of St. Paul's Cathedral he made a circle about 16 inches in diameter of rubber tubing, allowing the ends to overlap about three inches. In the small space between ends of tube he produced ripples which crept around the inner edge of the tube much as Rayleigh explained the phenomenon in St. Paul's. This sheet metal ring is substituted for the tubing. The whisperer directs sound along wall and the trap does the same with ripples. Mr. Davis' experiment is responsible for my presenting these simple demonstrations today.

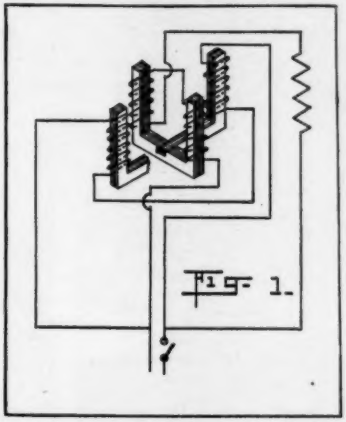
Rotating Magnetic Fields

Leonard R. Crow

Research Director, Educational Electric Manufacturing Company

Many attempts have been made to produce a device for effective demonstration of rotating magnetic field phenomena which would be both instructive and impressive to the student. Very little has been accomplished in this direction.

A demonstration to be of the greatest value for instruction must be impressive or forceful and as simple as possible. In other words, because a certain demonstration or experiment is performed means little or nothing at all, but the manner in which it is performed gives it value. It was with this idea in view that the writer developed the special apparatus here described for demonstration of rotating magnetic field phenomena. The apparatus is well adapted to attract attention in many types of display or exhibition work and lectures, and the student's curiosity can be raised to a high pitch, producing an interest and state of mind most receptive for the principles involved.



The device provides for creating a rotary magnetic field especially adapted to actuate conductive elements in close proximity to or isolated from the stator. The conductive elements may be in the form of balls, cylinders, discs, cubes, rings, etc., and in most cases are to be confined in a shallow transparent receptacle isolated from the stator.

Although means is known for producing a rotary magnetic field and for utilizing such a field in spinning small metallic objects, this device embodies improvements over prior apparatus in that the field is so directed that it can be more effectively employed for the purposes desired. Thus, in lieu of a Gramme ring, the magnetic flux of which tends to travel within the ring itself in the plane of the ring, the writer utilizes, preferably, a set of four coils (Fig. 1) provided with laminated cores, one pair of coils being connected in series with a unit for retarding the flow of current to throw the same out of phase with the remaining coils, or the two pairs of coils may be connected to the wires of a two-phase current, and by the adoption of six poles a three-phase current could be used. Any of these set-ups can be employed to produce a rotating magnetic field, the lines of force of which arch across between diagonal poles of the pairs of magnets at the upper end of the apparatus and the effective strength of the rotating field is thus readily available for the purposes desired.

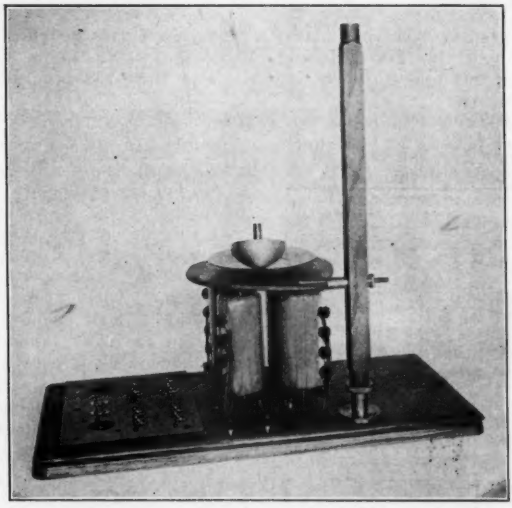
Another object of the device, therefore, relates to improvements in means of producing a rotary magnetic field, so localized as to be accessible without substantial interference by the apparatus creating the field.

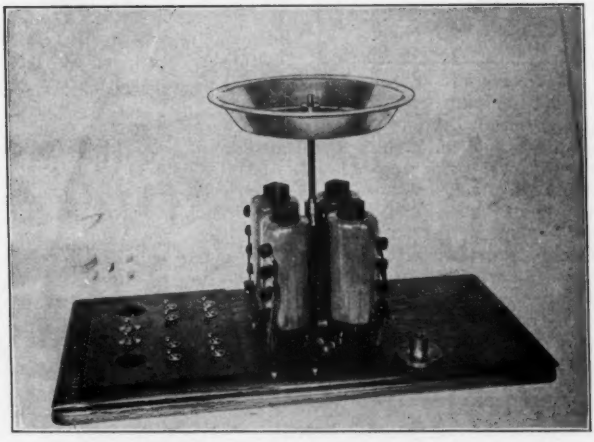
Many uses will suggest themselves from a consideration of the accompanying illustrations and drawings, wherein:

Figure 1 is a diagrammatic view showing the coil circuits and the preferred construction of the cores.

Figure 2 is an illustration showing an aluminum top which will spin in a glass dish placed upon a wood platform above the poles of the device.

Figure 3 is an illustration showing an aluminum pan which will rotate 4 or 5 inches above the poles of the stator.





Instead of the top illustrated in Figure 2, conductive balls, cylinders, discs, cubes or rings could be substituted.

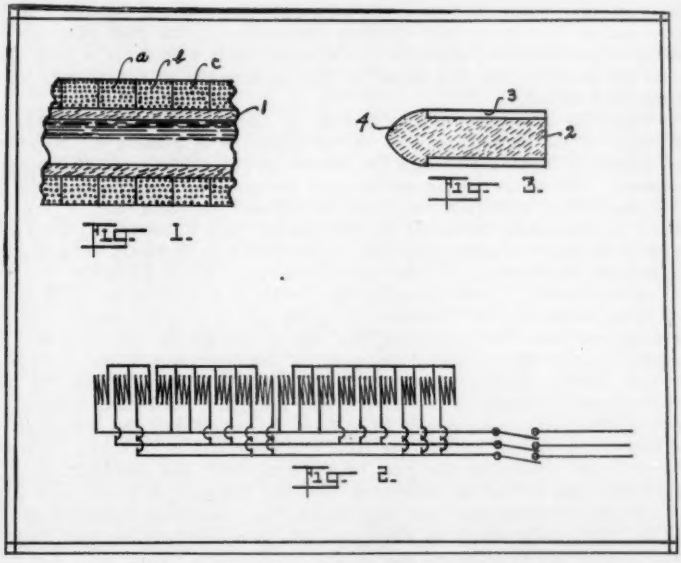
A small commercial squirrel cage rotor could be substituted for the aluminum pan in Figure 3. Thus many other varied experiments and demonstrations can be performed in an amusing, impressive and highly educational manner with this type of demonstration device.

A Polyphase Electric Gun

Leonard R. Crow
Research Director, Educational Electric Manufacturing Company

For many years engineers and other scientists have given serious thought to the design and development of a practical gun capable of discharging projectiles by the use of electricity instead of some type of explosive. All such guns so far devised have had some type of contactor system whereby the movement of the projectile, as it passed through the gun barrel, opened and closed contacts to effect its discharge.

The demand for an enormous amount of power delivered over a short interval of time as required to effectively discharge a projectile is a factor in itself sufficient, in most cases at least, to make the use of electricity impractical as a power for shooting projectiles.



The type of electric gun here described is a great improvement over other electric guns, although the description is presented not with the thought of practicability but from an educational point of view.

One of my chief objects is to provide a simple and efficient construction for discharging the projectile which consists in generating traveling magnetic fields, annular in form, propagated in the direction of the desired line of flight of the projectile by means of polyphase electric current.

As illustrated in figure 1, the gun barrel preferably consists of an innertubular member *1* provided with a clear unobstructed bore open at both ends, which constitutes the guideway for the projectile. This inner member should have high resistance to electric currents, which provides a substantially equal distribution of flux around the gun and prevents any possible tendency to shoot member *1* and energy loss due to eddy currents.

Surrounding the tubular member *1* is a series of annular coils *a*, *b*, *c*, arranged in successive groups and extending from the breech to the muzzle of the gun. The several sets of annular coils constitute means for producing traveling magnetic fields, which are propagated longitudinally of the gun barrel from the breech toward the muzzle and which, when a projectile of appropriate material is placed in the bore of the gun at the breech, induce currents in the projectile, thereby setting up a force tending to move the projectile through the gun toward the muzzle.

As illustrated, the coils are supplied with current of the alternating three-phase type, but current of any other polyphase type might be employed by proper arrangement of the coils.

The muzzle velocity of the projectile should be as high as possible, but it cannot exceed that of the traveling field which must therefore be maintained as high as practicable. The velocity of the traveling field is proportional to the pole pitch and the frequency of the inducing current so that by varying either one or both of these factors, the velocity of the traveling field may be correspondingly varied. One way of varying the pole pitch is shown in figure 2; the first three coils are connected to the polyphase system to form one pole, the following six coils are connected to the same system to form a pole of twice the length of the first pole, the following nine coils are connected to the same system to form a pole three times the length of the first pole. In this manner the pole pitch may be increased indefinitely.

When the frequency of the current in the gun coils is constant, the frequency of the current induced in the projectile is highest at the breech and gradually decreases toward the muzzle as the velocity of the projectile increases. The forces acting on the part carrying the induced currents are a maximum for a certain frequency of induced currents, and if the frequency is decreased, the forces fall off quickly, and if increased, the forces decrease slowly from said maximum. Therefore, it is decidedly advantageous to maintain the frequency of the induced currents in the projectile constant, and of such value as will maintain the forces at a maximum. This result can be approximated for practical purposes by making the velocity of the traveling magnetic field comparatively low at the breech and gradually increasing toward the muzzle of the gun. If the frequency of the current in the gun coils is constant, the result can be attained by varying the pole pitch, making it small at the breech and gradually increasing toward the muzzle. The same result may be effected by increasing the frequency of the impressed current during the time the projectile is traveling from the breech to the muzzle of the gun, or by connecting the successive sets of coils on the gun to current sources of different frequencies, which vary from a relatively low frequency near the breech to a maximum frequency at the muzzle. Obviously, either of these two last methods may be used in conjunction with the variation of pole pitch.

The projectile consists of either a solid or a hollow body of metal which may be of an appropriate shape, common to shot or shell. Figure 3 shows a projectile with a soft iron core (*2*) surrounded by a copper or aluminum conductive cylinder (*3*). The nose (*4*) may be of any suitable material.

When the inducing current is of very high frequency the magnetic circuit is not especially provided for, but the good electrical conductivity of the projectile is of great importance regardless of any frequency employed.

In order to increase the efficiency of the projectile as an element of the electrical system which effects its discharge from the gun, the walls of the shell should ordinarily be as thick as possible, and the material of which the conductive element of the shell is formed should possess high electrical conductivity.

Some Topics in Physiological Mechanics

Ira M. Freeman
Central Y. M. C. A. College, Chicago, Illinois

Physiological mechanics examines the living body from the viewpoint of the engineer. If we begin by considering the human skeletal system, we find that the physical and chemical properties of the bone materials are important factors in determining its mechanical characteristics. The rigidity of the bones is attributable mainly to calcium salts. A 5 mm. cube cut from the tibia of a cow will carry a load of 426 kg. when fresh, but withstands a stress of but 68 kg. after the calcium has been extracted chemically, a decrease of about 84 per cent in ultimate strength.

When an engineer wishes to exhibit the elastic behavior of a structural material, he usually records the data in the form of a stress-strain diagram. Such curves have been obtained for bone materials. The curve for compact bone is similar to that for wood. The average tensile strength of human bones is about 10 kg./mm.^{2} or 1,420 lb./in.^{2} According to Fessler, the humerus of the cadaver of a 25 year old male has a tensile strength of 800 kg.

The distribution of stress in an engineering test specimen may be represented by drawing the so-called lines of stress, and the object itself may then be considered, for purposes of elastic theory, to be replaced by fibers following the lines of stress. One set of these fibers will be in a state of compression, the other in a state of tension. Culmann computed the stress distribution for several members of the human skeletal system and found a striking similarity in appearance between the cellular structure observed in bone sections and the theoretical stress line diagrams. Even in the case of the knitting of a broken bone or in ankylosis, i. e. growing together of bones at a joint, the new bone structure develops in accordance with the new stress requirements. Wolf's observations correspond well with calculations made by Roux for curved beams. The fact that the cellular structure follows the lines of stress means that the bones are made of the minimum amount of material necessary for the fulfilment of their structural requirements, a most remarkable instance of adaptation.

The connective tissues of the body present mechanical problems which are even more interesting. Aschoff showed that the pathological changes accompanying arteriosclerosis are due to loss of resiliency of the walls of the vessels because of atrophy of the elastic fibers.

Even the simplest considerations of tissue elasticity have important clinical applications. Alterations in the colloidal state of the connective tissues manifest themselves as changes in hardness, resiliency and rigidity, and are clinically observable in the form of constitutional abnormalities or as local symptoms like the edema accompanying certain heart and kidney diseases. Special instruments have been devised to make quantitative measurements of tissue resiliency.

The extensibility of the muscles is, from the very nature of these organs, a question of importance. It is found that under the influence of applied forces an extension of about one per cent is produced by a unit stress of 4 gm./mm.^{2}, which is equivalent to 5.68 lb./in.^{2} The stress-strain relations

for a muscle are represented not by a straight line but by a curve which approaches an asymptotic value of the extension.

The maximum force exerted by the human calf muscle is about 6 kg./cm.^{2} and that developed by the biceps is 10 kg./cm.^{2} The greatest contraction in length of human muscles is 60 to 80 per cent of their natural length. Certain muscles of the frog are capable of over 80 per cent contraction, while insects possess muscles which are able to shorten by 97 per cent of the natural length.

In dealing with the statics of the body as a whole we come upon such problems as the determination of the position of the center of gravity. For the extended position with arms at the sides the center of gravity is in the median plane about 4 cm. above the line joining the hip joints. Knowing the relative weights of the various portions of the body and the position of the center of gravity of each, the location of the center of gravity of the entire body in any position may be computed in the usual manner. O. Fischer has devised an interesting linkage mechanism for experimentally locating the center of gravity without resorting to the rather troublesome calculations.

Kinematics finds a most interesting application in studies on the locomotion of the body. The act of walking has been referred to as a kind of repeatedly arrested falling process, but it is more accurate to analyze this activity by considering the cycle divided into three distinct phases:

In the first of these, the leg swings forward preparatory to assuming the weight of the body, whose momentum carries it forward and upward. Extension of the leg by flexure of the knee joint raises the center of gravity an additional amount. Work is done by the muscles during this time.

During the second phase, the foot reacts on the ground with a rolling motion from ankle to toe. In the third phase, the other leg is swung forward by the action of the hip muscles. This is accompanied by bending of the knee and dorsal flexure of the foot. This completes the cycle.

Running differs fundamentally from walking in that one foot leaves the ground before the other makes contact. In addition, contact of the heel with the ground is normally absent.

Energy changes accompanying vital processes in the body were, from earliest times, suggestive of an analogy between the living body and a thermal engine. The maximum mechanical efficiency of the human system is about 34 per cent. The rest of the energy appears as heat. Of this part, 60 per cent is lost by radiation, 25 per cent by vaporization of water and 15 per cent by convection. The maximum mechanical efficiency is attained, however, only in certain types of activity, e. g. walking. If the energy is expended in turning a crank the efficiency is only about 20 per cent, while for work done in rajsing weights the figure is a little over 8 per cent. The results are functions of the subject's diet and his practice and training in the activity under consideration.

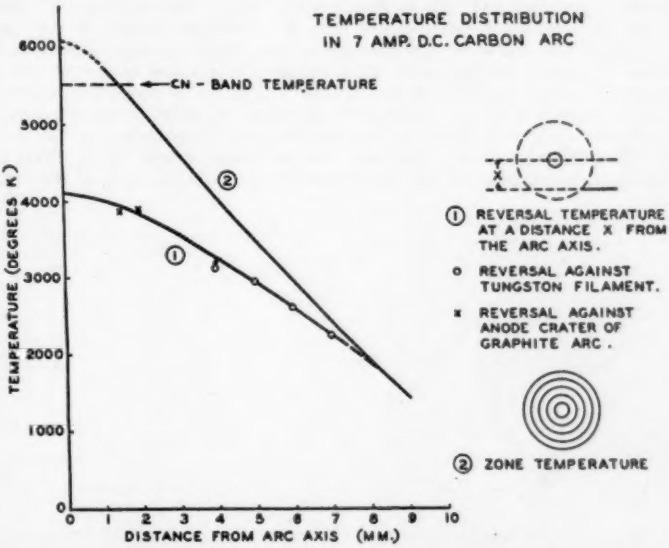
It may be said that the contemplation of the human body from the mechanical point of view has led to a functional orthopedic science. These studies are of value not only in clinical medicine but also in such applications as the improvement of human efficiency in industry.

The Temperature of the Gas in an Interrupted Carbon Arc

William T. Gray
Northwestern University, Evanston, Illinois

The temperature of the gas space in the electric arc has been the subject of many recent investigations. Knowledge of this temperature is of importance in studying the mechanism of the electric arc, and as a means of determining the temperature variation of gas-kinetic constants.

In the research problem upon which I have been working with Prof. W. S. Huxford, we have applied an established method of temperature measurement to the arc gas, namely the method of spectral line reversal. As is well known, when radiation from a black body is passed through a cooler gas containing a metal vapor the resonance lines of the metal appear as absorption lines. Conversely if the gas is hotter than the black body source, the lines appear bright. But if the temperature of the gas is the same as that of the black body, the lines disappear against the continuous background.



In our application a spiral tungsten lamp filament was imaged in the gas space of a 4 mm. D. C. arc between two "National Projector" carbons. This filament image and the arc were in turn imaged upon the slit of a spectrometer, in which the reversal of the Na-D lines was observed. The

black temperature of the lamp was determined by viewing with an optical pyrometer through a lens identical with that forming the filament image at the arc.

Reversal temperatures taken at various distances from the arc axis are shown in the figure. The range of the temperature measurements was extended by using the anode crater of a graphite arc as a black body source. For further analysis the arc was divided into concentric zones of uniform temperature. The reversal temperature at each distance is that corresponding to the intensity of radiation coming from all zones intersecting the light path, each zone being weighted by the product of the path length and the sodium density in that zone. Assuming that the sodium density is a constant fraction of the total gas density throughout the arc, the sodium concentration is inversely proportional to the temperature. The zone temperatures shown were calculated upon this assumption. The average temperature within a cylinder of 2 mm. radius about the axis is 5750°K. This cylinder coincides with the violet kernel of the arc, from which the CN bands are emitted. From the relative intensities of the rotational lines in these bands in the same arc, we have computed the rotational temperature of the CN molecules as 5500°K. The difference between these results is well within the limit of experimental error.

Thus far the existence of temperature equilibrium at each point in the gas space has been assumed. However the electric field, because of its acceleration of the ions and electrons, may disturb the Maxwellian velocity distribution. In order to eliminate this possibility we have turned to an interrupted arc, in which we observe the Na-D lines in the absence of a field. A synchronous commutator shunted across the arc short-circuits it for 1/240th of a second, then allows it to burn for 1/240th of a second. A disc provided with slits and run in synchronism with the commutator allows light to pass into the spectrometer only at a definite instant of the cycle. By rotating the stator of the disc-motor the phase of observation can be shifted. Reversal temperatures were taken through the center of the interrupted arc as a function of the phase. The curve of these temperatures, extended backward in time, intersects the point of cut-off at about 4000°K. This agrees very well with the central reversal temperature in the D. C. arc. Thus we have shown that the reversal temperatures upon which the distribution curve depends are not affected by the electric field in the arc.

A Modified Form of Fabry-Perot Interferometer

R. C. Machler

Northwestern University, Evanston, Illinois

Because of the vanishingly small transmission coefficient of silver films for which the reflection coefficient is above 90 per cent in the visible spectrum, Professor R. A. Fisher and the writer have found it of considerable advantage to rule the first of the interferometer films with parallel slits.

By properly choosing the separation of the slits and the width of each slit one can modify the Fabry-Perot interferometer so as to give the same resolving power with considerably greater intensity in the fringes. The increased photographic speed minimizes the effects of change in temperature and atmospheric pressure on the fringes. [Time of exposure was reduced from 4 hrs. to a few minutes in certain cases.]

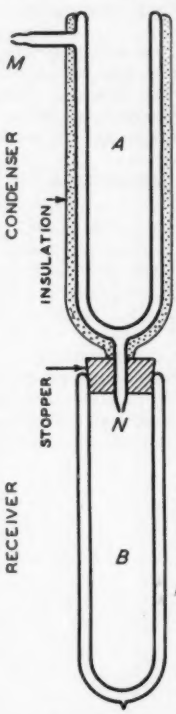
An ivory stylus mounted in a dividing engine head serves as a convenient and safe means of ruling the film.

An Easily Constructed Oxygen Liquefier

Chas. R. Marsh

Todd School for Boys, Woodstock, Illinois

The most attractive feature of this liquefier is its extreme simplicity. It consists essentially of two test tube shaped thermos bottles, one placed above the other (Fig. 1). Both are unsilvered. The upper bottle is modified by the addition of two short tubes or nipples attached to the outer wall and opening into the space between the walls. One nipple is placed near the top. The other is attached at the bottom and in line with the axis of the thermos bottle as shown in the figure. This lower nipple passes through a rubber stopper firmly inserted in the mouth of the lower thermos bottle. The upper bottle is insulated by a layer of hair felt.



The upper vessel may be styled the condenser. The lower is to receive and store the liquefied gas, in this case, the liquid oxygen. To operate, it is only necessary to fill A with liquid air. Then connect the nipple M through a pressure tube to a steel tank containing the gas oxygen. A pressure gauge (Hoke gauge) or an open-end mercury manometer must be included. Everything is now in readiness for the operation of the liquefier. The valve of the gas cylinder is opened carefully, allowing the pressure in the liquefier to rise until the gauge records, say, two atmospheres absolute. In a few moments liquid oxygen will begin to trickle down through the nipple N and collect in the thermos bottle B. The mechanism within A is simply that of condensation under pressure of the gas oxygen. This condensation takes place on the chilled wall of the condenser that is in contact with the liquid air. The condenser, of course, should be kept filled (or nearly so) with liquid air. Under these conditions, the liquefaction of the gas oxygen proceeds quite rapidly. An idea of the speed and efficiency may be gained from the following results of a test run. With the gas oxygen under 20 pounds pressure, absolute, and the liquid air about 6 hours old (its temperature being about –190° C) 100 cc of liquid air cooled the apparatus from room temperature and in 8 minutes produced some 20 cc of liquid oxygen.

The apparatus was actually constructed from four pyrex test tubes of 15 cm length, 25 and 32 cm diameter respectively.

This liquefier may be used in the liquefaction of other gases as well, the only requirements being that the cooling agent be colder than the resulting liquefied gas.

Design of Some Elementary Physics Laboratory Apparatus

Clarence J. Overbeck
Northwestern University, Evanston, Illinois

The apparatus of any laboratory is a silent but forceful teacher of the subject. In physics especially its design plays a considerable part in helping the student to learn what the laboratory work aims to teach him. In a course which introduces the subject to him the prime requisites for the apparatus are simplicity, ruggedness and a fair degree of accuracy of results.

The four pieces of apparatus shown, rather schematically, in the diagrams have proved helpful in our freshman laboratory at Northwestern.

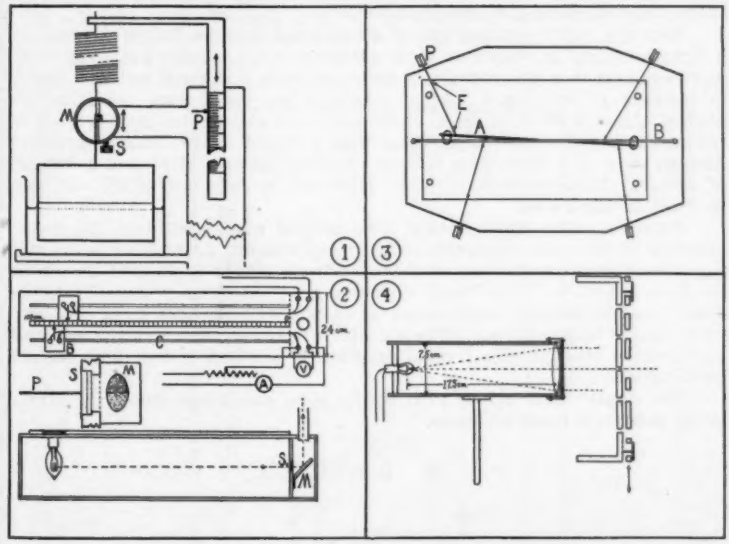


Figure 1. In the direct measurement of surface tension the force required to draw a horizontal wire from the liquid surface is measured. To obtain good results this wire must be of very small diameter and preferably rather long. To also have the stability necessary for repeated handling by first year students, a frame was made of nickel wire (0.76 mm. dia.), and fine tungsten wire (0.12 mm. dia.) used for the measurement was spot-welded across its face. This frame attached to a Jolly Balance (described in the "American Physics Teacher" Feb. 1935) is slowly drawn from the liquid keeping the spring index and its image always on the hair-line of the mirror *M*. A screw *S* is used to raise and adjust the mirror as the frame lifts from the liquid. The scale reading *P* is made when the film breaks. Then the

spring frame is lowered to the same cross-hair setting without the film and a second reading made. The difference between the two readings gives accurately the spring elongation, due to the film. The student then calibrates the spring, using known masses, and measures the length of the tungsten wire.

Figure 2. A measurement of the luminous efficiency of carbon filament and Mazda lamps is made the connecting experiment between electricity and light. A daylight type of photometer box was designed for this purpose. The upper drawing shows the top view of the box cover, and the lower drawing the inside side view. The middle drawing is an enlarged top view of the comparison screen *S* and mirror *M*. The standard lamp and lamp to be tested are separated by a black sheet metal partition *P*. In making a reading the bases *B*, to which the lamps are attached through slits *C*, are slid back and forth until the two halves of the circular screen at *S* (dia. 2 cm.) are equally illuminated as seen in the mirror. Since tests are run on different lamps operated at different voltages the color trouble tends to make comparison difficult. This is practically avoided by placing glass Corning Filters Nos. 349 and 430 over the fine tracing paper of the screen. These filters permit a comparison for a quite narrow band with a maximum at approximately 5700 Å and give results which are in fair agreement with those obtained using a flicker photometer.

Figure 3. The "Equilibrium of Forces and Torques Board" consists of a light brass rod *A* with four cords running over the pulleys *P*. The cords are loaded so that the rod clears its rings from the check rod *B*. Rod *B* is fastened to the board. After obtaining an equilibrium condition the student places a sheet of paper under the cords and locates the positions of the points *E* under each cord. This with a record of the loads is sufficient data to show that there is a balance of forces (graphically) and a balance of torques (mathematically). This apparatus is very instructive and may be built at small cost.

Figure 4. The Hartl Optical Disc method adds greatly to the understanding of the usual refraction of light experiment. Light sources for this experiment were constructed as shown, using a Mazda G. E. 1141 21c 12-16v lamp as a source. This lamp is found most satisfactory since it has a single straight filament which when set in line with the slits gives efficiently very narrow beams of light. The variable slit system shown in the enlarged cross-section view permits a rapid selection of any one of four different slit combinations.

The single center slit is used in the plate and prism study, the others being used in a study of lenses.

Protection of Multiple-Scale Voltmeters in the Laboratory

O. L. Railsback

Eastern Illinois State Teachers College, Charleston, Illinois

In the experience of the writer, the instruments most likely to be damaged in the general physics laboratory are the ammeters and voltmeters. In most cases, the ammeters can be fairly well protected by the use of fuses. The following method has been employed with marked success to give protection to the D. C. voltmeters:

The voltmeter is enclosed in a close-fitting box of panel board on which is mounted a series of switch points and switch, as shown in the accompanying diagram. The binding-posts are permanently connected in the order shown. A series resistance is connected to the first "on" position. The value of this resistance is about ten times that of the high resistance of the voltmeter. An ordinary radio resistance is used since its value is not critical.

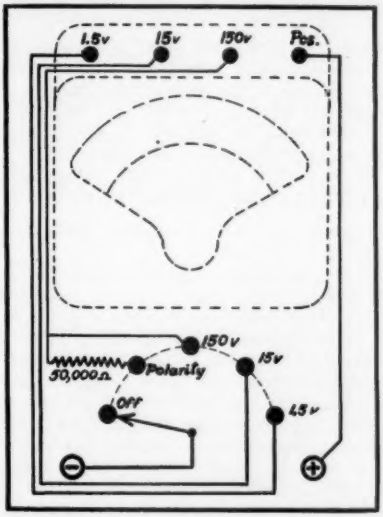


Fig. 1.—Wiring diagram.

Its purpose is to protect the voltmeter needle from a hard blow in case the voltmeter is connected backwards to the circuit. When these instruments are first placed in the hands of beginning students, the following precautions are emphasized:

(1) Always have the switch in the "off" position when connecting to a circuit, or when changing connections of the circuit.

(2) Watch the voltmeter hand as the switch is moved forward. If the deflection is backwards in the first "on" position, do not advance the switch, but reverse the connections on the voltmeter.

(3) Never advance the switch to the next point without making sure the voltage is less than the maximum scale-reading for the next contact point.

These rules of procedure are more easily understood, and carried out by the beginning student than if he is using the ordinary type of multiple-scale voltmeter with several binding-posts.

The use of this instrument offers the following advantages:

(1) A reversed connection may be detected without throwing the full voltage of the circuit on the instrument, because of the high protective resistance.

(2) The setting to the proper scale is always made from the high scale down.

(3) The student may change from one scale to another easily and quickly, thus avoiding the usual temptation to "guess" the proper scale without starting at the highest.

(4) There are only two binding posts exposed, clearly marked plus and minus, respectively, thus reducing the chances of wrong connections.

Thus it is possible to considerably increase the protection afforded the instrument, and at the same time actually to make its use much more convenient and rapid. The writer has tried placing unprotected voltmeters among the protected ones, from which the students might select their instruments. Invariably the protected ones are chosen because they are easier to use.

Before the adoption of this method of protection, the largest cost for repair in the general elementary laboratory was for voltmeters. Since its adoption, damage to voltmeters has become very rare.

The Weston Type 280 voltmeters were used because of their small size. The method could, of course, be adapted to any voltmeter. The cost of protecting a voltmeter is approximately two dollars.

This method of protecting multiple-scale voltmeters was planned and executed jointly by Samuel P. Mitchell and the writer.

Models of Thermodynamic Surfaces

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The photographs show models of thermodynamic surfaces showing the P-V-T relations for two typical substances, water and carbon dioxide, including the solid phase as well as the liquid, vapor, and gas phases.

The models are of course dimensionally quite diagrammatic in order that the volume changes of the liquid and solid phases be visible. They are nevertheless very useful in clarifying the P-V-T relations. The graphs are easily traced on the models themselves and are readily explained when the models are at hand. They show in a clear-cut fashion a few of the more elementary but interesting P-V-T characteristics, which Bridgman discusses exhaustively in "The Physics of High Pressure"[1] and elsewhere.[2]

Water is one of the few substances that shows a diminution of volume during fusion; the others are cast iron, gallium and bismuth, the latter two of which have been examined in the physicist's laboratory, along with water. This diminution of volume is thermo-dynamically associated with a negative $\left(\frac{\delta p}{\delta t}\right)_v$ according to Clapeyron's equation, that is to say, the melting temperature falls as the pressure is increased. Water and bismuth,[3] however, revert to the more common type of behavior at sufficiently high pressures, water at 2200 kg/cm.[2] and bismuth at 25000 kg/cm.[2]

Of the six forms of ice known, only Ice_I is abnormal. The first graph shows the transition from Ice_I to Ice_II and the melting curve between water and Ice_II, which curve has a positive $\left(\frac{\delta p}{\delta t}\right)_v$. There is a change of approximately 20 per cent[4] in going from Ice_II to Ice_I as compared with the 8 per cent change for Ice_I to water, an increase in the first case and a decrease in the latter. These changes are clearly shown on the model.

All substances so far tested show P-T melting curves concave toward the P axis. As to the ultimate behavior of the melting curve four theories have been advanced, a critical point as in the case of liquid-vapor, a maximum temperature, an asymptotic temperature, and an indefinite rise, the last by Bridgman.[5] The first two have not been realized in the experimental pressure range, and the last two depend on extrapolation, so that the problem is not definitely answered at the present time.

The P-T curves are not strictly isovolumic curves; they are rather the important lines seen in a side-view toward the P-T plane. The triple point is a point for P and T; it is a triple point line for V.

These surfaces were first modeled in clay, negative plaster casts made from the clay models, and positives cast from the negatives. A little paint preserves the surfaces and makes them more distinct.

[1] P. W. Bridgman, The Physics of High Pressure, (Macmillan, N. Y., 1931).
[2] P. W. Bridgman, Reviews of Modern Physics 7, (1935).
[3] P. W. Bridgman, Phys. Rev. 45, 844 (1934).
[4] P. W. Bridgman, The Physics of High Pressure, page 242.
[5] P. W. Bridgman, Phys. Rev. 46, 930 (1934).

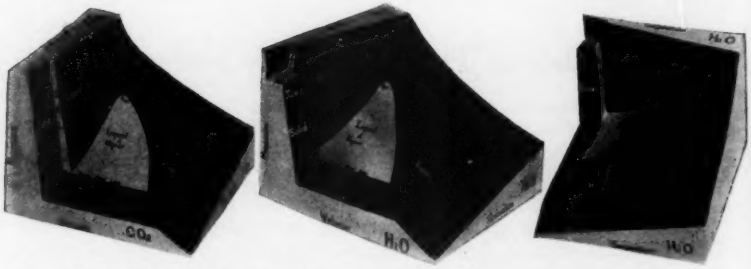

Fig. 1.—Models of thermodynamic surfaces showing the P-V-T relationships for carbon dioxide and water.

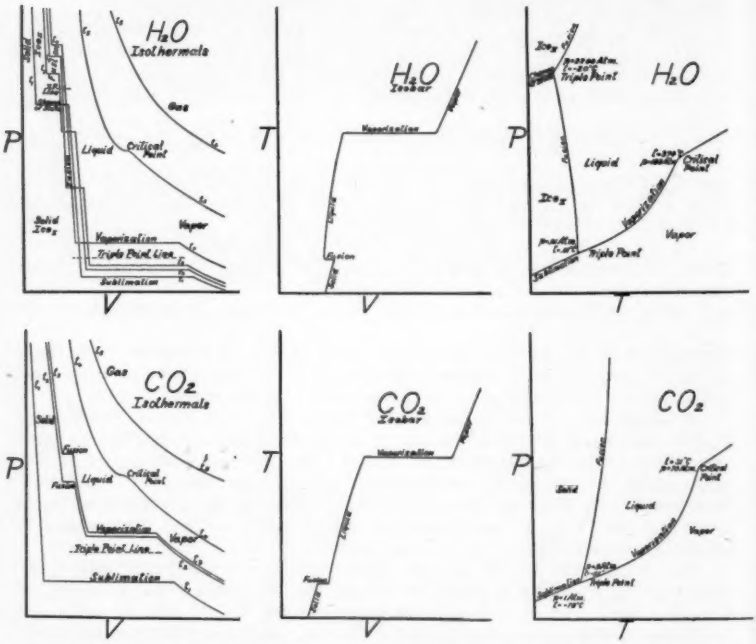

Fig. 2.—Graphs showing the same P-V-T relationships that can be traced on the models.

PAPERS IN ZOOLOGY

EXTRACT FROM THE REPORT OF THE SECTION CHAIRMAN

The program of the Zoology Section consisted of nineteen papers, six of which were not presented at the meeting and one of which was read by title only.

The following was read by title: "Studies on the Biology of the Crayfish, *Cambarns, propinquus Girard*," by William C. Van Deventer, Rochester, New York.

The following, although read at the meeting, was not presented for publication: "The Family Life of the Blackbellied Tern," by Charles K. Carpenter, Chicago.

Attendance at the meeting averaged thirty; maximum attendance was forty-two.

No election of chairman was held.

(Signed) L. A. ADAMS, *Acting Chairman.*

Dental Variations of the Dog, *Canis domesticus*

L. A. Adams

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The following notes on the anomalies of the dog dentition were obtained from the observation of over a hundred skulls that were prepared for the use of university classes in vertebrate zoology. The dogs were supplied by a department that uses many animals, and the source was the pounds of the surrounding cities. The collection was quite representative, consisting of animals of all sizes, and short-headed, long-headed, and intermediates. The dentition was surprisingly good for animals that had to depend upon themselves for a balanced dog diet.

The dental formula of the dog has been fixed since the upper Miocene and it is to be expected that the formula $\frac{3\text{-}1\text{-}4\text{-}2}{3\text{-}1\text{-}4\text{-}3}$ should be quite stable. Earlier in carnivore history there was a shifting forward of the shears and we find that in Hyaenodon the shears were on $\frac{M^2}{M_3}$, in Oxyaena on $\frac{M^1}{M_2}$, while in modern canines it is on $\frac{Pm^4}{M^1}$. The dental formula was quite stable in the series examined with little deviation except in the last molar and in the first premolars. The skulls were examined for the following anomalies; missing teeth; duplication of teeth; decayed and abscessed teeth; and irregular alignment. In no case was there any irregularity in incisors or canines.

Missing teeth:

First premolar missing bilaterally on skull.
First premolar missing unilaterally on three mandibles.
Second premolar missing unilaterally on three mandibles.
Third premolar missing bilaterally on one mandible.
Fourth premolar missing bilaterally on two pairs of mandibles.
Fourth premolar missing unilaterally on one mandible.
(Molars 1 and 2 were always present.)
Third molar missing bilaterally in four cases.
Third molar missing unilaterally in three cases (mandible).

Duplication of teeth (confined entirely to first premolar).

First premolar with bilateral duplication on two pairs of mandibles.
First premolar duplicated unilaterally on one mandible.
First premolar duplicated unilaterally on one skull.
First premolar duplicated bilaterally on one skull.
First premolar incompletely doubled on two mandibles (unilateral).

Decayed teeth:

Dental caries were found in but one skull and in two pairs of mandibles.

Abscessed teeth:

Abscessed teeth were found in three specimens only.
Third premolar of mandible with large abscessed area.
Fourth premolar with a large abscess around its roots (mandible).
One mandible with a pair of abscesses under the first and second molars of both rami of the mandibles.

Teeth out of alignment:

Four cases were found in which there was a crowding of the teeth so that they were out of alignment. This was in the short-headed animals. The premolars were concerned in this crowding.

It appears that for the most part, dogs have very little trouble with their teeth. The greatest danger appears to lie in abscessed teeth, although this was found in but three cases. It seems probable that these abscesses are caused by spikes of bone that are driven down into the bone and jaw, while crushing bones eaten as food. These abscesses were always associated with the posterior premolars, or with the molars. The few cases of decayed teeth indicate that it occurs rather infrequently, and probably always associated with some chipping or accidental break in the tooth. The crowding of teeth in some specimens was such as to make the occlusion of the teeth rather poor and the dogs with the mixed heredity appear to suffer somewhat from dental failures.

Rearing Codling Moth Larvae for Testing Insecticides

M. D. Farrar* and E. R. McGovran†

State Natural History Survey and University of Illinois Agricultural Experiment Station

Introduction.—The codling moth, *Cydia (Carpocapsa) pomonella* L. is an insect extensively and intensively studied by many research workers. Actually thousands of articles are printed dealing with the codling moth, mostly in scientific publications. It is a serious pest of apples and other fruits in all parts of the world. The majority of investigations have been made to improve the control. In addition to work on control, research has been done dealing with the development, habits, parasites, tropisms, metabolism, digestion and ecology. The effect of temperature on this insect was exhaustively studied and more recently the variations in resistance to poison of strains of codling moth from different sections of the United States are being investigated.

The life cycle of the codling moth may be one, two or three brooded, depending entirely on temperature relations and length of season. Three full broods occur in southern Illinois while one and a partial second is normal for extreme northern sections of the State. In all cases it overwinters in the larval stage. Larvae spin into cocoons, usually on the trunk of the tree. With favorable spring temperatures, pupation occurs and development proceeds more rapidly.

Generally between May 10–30, first summer generation larvae will be entering apples. As much as three weeks variation in season may occur between southern and northern Illinois.

In Table I, life history data collected by Glenn (1922) at Olney, Illinois, illustrates seasonal history typical of the insect in most sections. Each generation is considered to start with the egg stage and end with the adult moth.

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† Research Assistant in Entomology, State Natural History Survey and University of Illinois Agricultural Experiment Station.

TABLE I—DAYS FOR CODLING MOTH TO DEVELOP

Stage of development	Hibernating generations			Summer generations		
	Minimum	Maximum	Average	Minimum	Maximum	Average
Egg	5	15	7	6	13	9
Larva (feeding)	16	54	29	14	43	25
Larva (total)	244	305	265	18	47	26
Pupa	18	46	31	8	14	11
Adult	4	28	12	3	15	7
Total life	287	330	315	43	66	53

Technique.—In order to secure data on the toxicity of insecticides against codling moth, it is necessary to produce larvae for standardized tests. Farrar and Flint (1930) published an article dealing with the production of larvae out-of-season. Since that time many refinements have been added. Many of them are reported in this paper. The use of equipment for control of temperature and humidity has made possible the production of about 25,000 larvae for the testing of new insecticide mixtures during the winter months. Mature apples have in all cases been sprayed and infested with larvae.

Collection and Storage of Larvae.—To rear enough newly hatched larvae for insecticide tests, thousands of hibernating larvae must be secured. The daily emergence of 200-500 adult moths provides a good working basis for tests. During the active season collected larvae will develop to maturity, but after temperatures below 50°F. arrest pupation (about August 15 at Urbana, Illinois) a storage period at low temperature is necessary before development will continue. The most economical collections of larvae for tests are made after normal pupation stops. Corrugated paper bands two to four inches wide placed around the trunks of apple trees bearing a crop of wormy fruit catch many larvae. Scraping the trees free of rough bark will aid materially in inducing the larvae to enter bands. Similar strips of corrugated paper tacked against the walls of bins containing cull apples yield quantities of larvae.

By the latter part of September the bands should be removed and stored, preferably out-of-doors. Protection should be provided against mice and temperatures of lower than 10°F. below zero as either can quickly destroy the collected larvae.

Fall collected larvae if brought indoors January 1st will start to emerge about February 15th. The larvae will pupate more uniformly and in greater numbers if their hibernating cocoons are thoroughly soaked with water before placing them at higher temperatures. Before pupation starts in the spring, unused over-wintering larvae may be placed in cold storage at 40°F. or less. Here they may be safely kept for 6-10 months without undue loss, provided they are not allowed to dry out or mold. Larvae kept in storage past their normal emergence date will emerge in 3 to 4 weeks when exposed to summer temperatures.

Emergence and Collection of Adults.—A room 6 x 6 x 6 feet is convenient for an emergence chamber. Such a room will provide ample space for storage of larvae in corrugated paper and for the collection of adults. For maximum production 80°F. and 80-90 per cent relative humidity is desirable. For the convenience of handling adult moths, a window in one side fitted with an oviposition cage will attract at least 50 per cent of the adults without attention. A cheese cloth lining of the interior of the room serves as an excellent background for the collection (by suction) of those moths not attracted to the lighted window. As protection against mice, the larvae are stored in trays with one-fourth inch gravel screen tops and bottoms. The moths emerge from their cocoons in the corrugated paper, crawl through the one-fourth inch screen and fly to the light.

The oviposition cage was designed to save time in handling moths. It is essentially a wooden frame three and one-half inches wide and twelve inches square. To each side is hinged a light frame twelve by twelve inches covered with screen wire. In assembling the cage, the inside of the wooden frame is first lined with perforated cellophane. A twelve by twelve sheet of the same material is then slipped into each side, thus completely lining the cage. Adult moths are collected daily into an oviposition cage. Many moths will enter the cage unhandled if the one side of the cage is lowered and the

cage is fitted into the window of the moth emergence chamber. Additional moths can be added through a hole provided in the top of the cage.

Oviposition.—This phase of larval production is the most exacting of all. Even with all precautions, not every collection of moths can be induced to oviposit. To stimulate egg production, two or three withered apples are placed in the cage containing 300 to 500 adult moths. This cage is set into the oviposition case where it is undisturbed for four days. As the number of hours of daylight is much less in February and March than when the adult moths are normally active from June to September, it has been found possible by the use of lights to increase the amount of oviposition by extending the number of hours of light to 14 or 15 per day. In the case housing the oviposition cages, the air must be clean and free from moldy odors. The case is operated at a constant temperature of 80°F. between 8 A. M. and 4 P. M. During the remainder of the day and night the temperature falls to approximately 70°F., room temperature. The relative humidity is controlled constantly between 70 and 75 per cent during the period of constant temperature. At night, with the falling temperature, the relative humidity approaches saturation, 90 per cent or higher. This rhythm of temperatures and humidities seems superior to any set of constants found.

At the end of four days the oviposition cages are removed and opened. All moths still active are collected and put into other cages. The cellophane lining coated with eggs is removed and cut into strips suitable for storage in hatching boxes.

Incubation of Eggs.—Hatching boxes may be of several designs. Mailing tubes or cardboard or metal boxes will serve. In all cases glass shell vials 0.75 x 2.5 inches are fitted into the sides. Newly hatched larvae are attracted into these vials by the light. From these they are transferred by means of a camel's hair brush to the test fruit.

A special incubator is provided for the hatching of the eggs. As soon as the papers of eggs are removed from the oviposition cages and placed in the hatching boxes, they are set in this incubator until the young larvae appear. Here the temperature is maintained constant between 75° and 80°F., with a relative humidity constant of 80 per cent. A glass window in one side of the case admits light that in turn attracts the newly hatched larvae into the vials.

Infestation of Apples.—Apples to be infested are sprayed with the respective insecticides 24 hours in advance of the time larvae are to be transferred to them. With a camel's hair brush, 10 larvae are transferred to each apple. The infested fruit is then suspended in a constant temperature (80°F.) and humidity chamber (60 per cent relative humidity) for a period of 24 hours. During this time the larvae may establish themselves in the apples under very favorable conditions. The fruit are removed from the case after 24 hours and stored in a cool place for five days. On the sixth day after infestation, each apple is graded for the number of entrances and stings made by the codling moth larvae.

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The Bionomics of the Ladybeetles

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ABSTRACT

The ladybeetles are among our most popular insects. All of the midwestern species seem to pass the winter exclusively as adults. Some of the smaller forms live under large scale insects or in the nests of ants, but the most common ones are active on plant surfaces where they search for prey, and lay their eggs in masses. Most masses contain 20 to 30 eggs, and the daily production declines as the end of the ovipositional period of an individual is approached. Individuals of *Chilocorus similis* deposited an average total of 16 eggs while *Hippodamia convergens* produced an average of 731 per female in her entire life time. Incubation generally requires eight days or less, and the larvae are said to bear egg bursters on the thorax. Four instars compose the larval stage in almost all known cases. These are of relatively brief duration, the stage as a whole usually lasting from 16 to 30 days. The mature larvae attach themselves to exposed surfaces of objects by the posterior end of the abdomen, the means being either an anal secretion or a special caudal appendage. Larvae covered with waxy plates or fibers retain the last exuvium as a shelter for the pupal stage, but most ladybeetles shed this skin and crowd it back to the tip of the body. For most part, the pupal stage lasts a week or less, and the new adult remains quiet in the pupal skin until fully colored and hardened. The adults of certain common species lived from one to fourteen months in captivity.

One of the three subfamilies of the Coccinellidae is but little known and the second, which embraces our squash ladybird and Mexican bean beetle, eats exclusively plant tissues. The third group, or Coccinellinae, largely contains predacious forms, but the tribe Psylloborini is fungivorous. Plant lice, scale insects and red spiders are the principal prey, but other small soft-bodied Arthropoda form a part of their fare. However, even the predatory ladybeetles commonly take pollen and fungous spores with their animal food. According to some observations, only the liquid parts of the prey were ingested but some larvae and adults swallow the solid with the fluid parts. Their voracious feeding on aphids and scales makes ladybeetles of inestimable benefit to man, and they have accordingly been variously employed in biological control. The mass hibernating habit of *Hippodamia convergens* in California mountains favors its use in combating insect pests in the valleys. This, and some other species of the world, concentrate in masses of many thousand individuals at altitudes of about 10,000 feet, and occupy the same spots year after year. *Ceratomegilla fuscilabris*, a familiar species of the midwestern plains, commonly assembles in large numbers at the base of trees in the edges of woods.

The Occurrence of the American Eagle Along the Ohio River in Illinois

Clarence Bonnell

Township High School, Harrisburg, Illinois

The investigation here recorded was prompted by reading the pamphlet, "Save the Bald Eagle", published by the Emergency Conservation Committee, New York City, and recently distributed by the Isaak Walton League.

About the year 1922, a large specimen of this bird was shot in the wing by Louie Gaskins and another hunter of Harrisburg as it flew over a slough northeast of Shawneetown. It was brought to our high school where it was kept until its wing healed and the characteristic white head of the adult appeared. It was then released. Since that time various newspapers of the locality have published numerous accounts of specimens being killed.

Rev. Fr. Sharbough of Shawneetown has a mounted specimen which was killed in the Wabash bottoms a few years ago. He reports that he has seen three or four eagles in that vicinity within the last year.

Reports indicate their greater prevalence about the Wabash River than along the Ohio in Illinois. Jake Lauderdale of Brownfield, Pope County (inland from the Ohio), reports seeing none for thirty years but has news of one being seen two years ago.

Harry Woolcott of Harrisburg who has a summer camp in Kentucky below Carrsville reports seeing one on a tree on the Illinois side across from his camp.

Captain William Hale of Shawneetown has seen bald eagles near Cave-in-Rock, Hardin County, within the last year, and formerly as many as six times a year, sitting on trees out in the bottoms but has never seen any nests.

Carl Eswine of Shawneetown who has spent most of his life on the Ohio and about the lakes of the Wabash bottoms says that from two to six eagles have spent the winter months within a radius of ten miles of the mouth of the Wabash, usually alone along the river, from autumn till spring. He knows of no nesting places.

William Zachmeier of Shawneetown who keeps the pilot lights from Shawneetown to the mouth of the Wabash says he has seen about six in the past two years, generally perched on trees near the river. He has seen as many as four at one time. They stay all winter.

James Daily of Ridgway, Gallatin County, knows of four that roosted back of his place along the Wabash bottoms between New Haven and Shawneetown during the last winter. He thinks he has seen from twenty to thirty in the past fifteen years, resting on trees or flying up and down the Wabash. Some are killed in the Wabash bottoms every year, he says, also, that some are said to nest in a place called "The Loops", about seven miles southeast of New Haven.

Bailey Williams, of Broughton, a teacher, lives on a farm near Big Hill, a lookout point in section 35, T. 6 S., R. 7 E. in southeastern Hamilton County. He remembers that a pair nested in a large post oak tree at the edge of the rocky slope on Big Hill about 1910 or 1912. The next year the

neighbors drove them off. His father, H. S. Williams, a former game warden living on a farm near New Haven, confirms the above and reports a nest seen in a big pecan tree near the Brushy Slough close to the Wabash four or five years ago. Bailey Williams saw one eagle near his home this year and one during the duck hunting season on the Wabash, three or four miles northeast of New Haven. A large one stayed near his home for three weeks during the winter of 1927. He is now caring for a young one which was shot in the wing and brought to him.

Another young one I found being cared for on the farm of a Mr. Walser near New Haven. Mr. Walser knew of rumors of nests up the Wabash near Mt. Carmel but claimed to have never seen any nests in Illinois himself. The two young captive specimens which I have seen recently are large which confirms the statement of Ridgway that the young frequently have greater measurements than the adults. Some fishermen and hunters of the Wabash bottoms distinguish the young ones as gray eagles and the adults as bald eagles in the belief that they are two different species.

Jack Street of New Haven says he has seen eagles at Yellow Banks, a slough emptying into the Wabash, but knows of no nests in recent years. Walser and Street and others interviewed at New Haven had no definite knowledge of present nesting places. It is evident that several eagles, mostly young ones, are killed in the Wabash bottoms every year. It is doubtful whether any nests are to be found, though I was not sure whether all of my informers would have told me if they knew of any.

The sentiment along the lower Wabash appears to be that the eagles should be exterminated. The usual tales of their destructiveness are current. Here is work for the Isaac Walton League or other conservationists. It would be interesting to know just where the young eagles that frequent the lower Wabash valley and the Ohio are reared. Should the two convalescent captive specimens be released, it would be worth while to have them banded.

The Effect of X-Rays on the Incubation Period, Sexual Development, Egg-Laying Capacity and Brooding Tendencies in White and Brown Leghorn Chickens

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Conflicting conclusions have been reached by various investigators who have studied the effects of x-rays on the developing chick embryo. In an effort to ascertain more clearly the destructive as well as the stimulating qualities of Roentgen rays, we have rayed a large number of hen's eggs at different stages of incubation and with various dosages. The chicks from eggs so treated have been studied before and after hatching. Many of them have been raised to maturity in order that latent effects of x-rays may be observed. The results are here recorded.

MATERIAL AND METHODS

Fertile eggs of reliable quality were used throughout the experiment. All were incubated before irradiation. The age of the embryo varied from 19 to 243 hours incubation. The young chicks were reared in a brooder and later, at 4 to 5 weeks old, transferred to a chicken coop, located on the roof of the Medical Building. The coop was so constructed as to protect the birds from excessive temperature changes, and supply plenty of space for exercise. The floor was covered with shavings which were changed once every week. Automatic traps were used for laying.

Young chicks were fed on "Purina Chicken Starter". Older birds received mixed grain in addition. All birds were given meat scraps and greens twice a week.

The x-ray machine used was a "Type C" model made by the Standard X-Ray Company. It was equipped with a Coolidge therapy tube and a Landauer Roentgenometer. The focal distance was 10 inches and the filter was equal to 4 mm. aluminum. The Roentgenometer was kept at 3.2 which, by calculation, delivered 0.6 r per second. The set-up of the machine remained constant for the duration of the experiment. The dosage varied from 30 to 600 r.

RESULTS

Effect of X-Rays on the Incubation Period.—The incubation period of all x-rayed eggs varied between 19 and 22 days. If the incubation period was expressed in hours and the data organized on the basis of dosage, the average incubation period for 30 r was 484 hours, for 80 r, 495 hours and for 400 r it was 501 hours. The controls averaged an incubation period of 496 hours, which is 8 hours less than the accepted 21 days. From these data, two significant facts are apparent. First, the incubation period in x-rayed

white and brown leghorn eggs varies directly with the x-ray dosage and secondly, small dosages, less than 80 r, accelerate development and dosages more than 80 r retard the developmental process.

Effect of X-Rays on Sexual Development.—In the experiment, sexual maturity was indicated in the female by the laying of the first eggs and in the male by a successful attempt at crowing. In the female, attainment of sexual maturity varied from 2 months 6 days after hatching to 5 months 14 days. The average was 4 months 14 days. The average in the controls was 5 months 17 days, an acceleration of 1 month 3 days in favor of the hens from rayed eggs. In case of the males, sexual maturity varied from 1 month 27 days to 2 months 24 days; the average being 2 months 9 days. The average for the controls was 3 months 5 days, which shows an acceleration of 26 days in case of the x-rayed specimens.

Effect of X-Rays on the Egg-laying Capacity.—The egg-laying capacity of 121 hens has been recorded. Of these 57 were hens from x-rayed eggs and 64 from eggs that had not been rayed. Of the experimental birds, there were some whose egg-laying record extended over more than two years; the majority extending over 1 and 1½ years; none are included in the calculation of averages if their egg-laying record did not extend beyond 8 months. The normal or non-rayed hens were used for other experiments as soon as their egg-laying became regular. The egg-laying capacity for the rayed birds averaged 8.8 per month which is very low as compared with normal capacity of Leghorn chickens. Data supplied by the poultry farms from which the eggs were obtained give the average of 18 eggs for pullets and 24 for hens per month. Several peculiarities were noticed in the history of rayed chickens. As a rule, the first egg-laying period was very active; some pullets laid from 20 to 26 eggs per month for 6 to 7 months. Then a gradual decrease set in which was followed by total cessation of egg production. Periods of rest of several months occurred, in some as long as 6 months, which was followed by another exaggerated laying period and another rest period. The subsequent laying periods were usually marked by shorter time and lesser productivity. The egg-laying course in the non-rayed pullets was different. Productivity during the fifth or sixth months after sexual maturity was irregular and low, averaging 6.8 per month.

BROODING TENDENCIES

It will be remembered that our flock of birds consisted of pullets and hens rayed in egg, non-rayed pullets which were rayed as soon as they began to lay regularly and of course, a few male birds. During the 5 years of experimentation, no definite brooding signs have been noted in the colony. Since we did not have non-rayed hens that would serve as controls, no claim of an x-ray cause for the absence of brooding can be made without further investigation.

Sex Conditions in a Japanese Valvata*

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Sex conditions in the genus Valvata, a group of fresh-water prosobranchiate snails, have until recently received little attention. Much study, however, has been directed toward other snails, but the most recent investigations have been made on the marine members of this group. Von Kemnitz (1914) first reported on sex conditions in *Valvata piscinalis* which were of

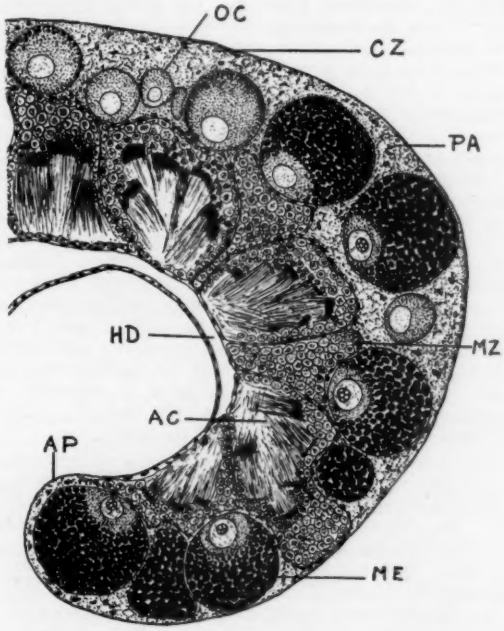

Fig. 1.—A diagram of a section of the hermaphrodite gland of *Valvata japonica*. The topographical relationship of the male and female zones is shown.

AC—acinus
AP—apical region
CZ—cortical zone (female)
MZ—medullary zone (male)
HD—hermaphrodite duct
PA—parenchyma
ME—a mature egg
OC—a young ovocyte

Bavarian origin. In these snails he observed no special deviations in structure or cell history and further stated that spermatogenesis occurs without complications or irregularities. Later, Artom and Cavallini (1931) found in *Valvata cristata* a tendency toward atypical spermatogenesis. While these

* Contributions from the Biological Laboratories of Knox College No. 48.

investigators recorded the finding of both atypical and normal (typical) spermatozoa in *Valvata cristata*, they also reported finding only normal spermatogenesis in *Valvata piscinalis*. Both of these species were collected in Italy.

In one of the American species, *Valvata tricarinata*, a higher degree of spermic abnormality has been observed (Furrow, 1931, 1935). In this species four distinct types of spermatozoa have been identified, only one of which follows a normal course of development. The other three types vary in their deviation from a condition which resembles the eupyrene spermatozoa to that of the aypyrene forms.

Through the courtesy of Dr. Denzaburo Miyadi of the Otsu Hydrobiological Station of Kyoto Imperial University, specimens of the Japanese species, *Valvata japonica*, have been placed at my disposal for study and comparison with other members of the genus. This Japanese snail resembles *Valvata sincera*, one of the American fresh-water prosobranchiates in its general external and anatomical features. The shell of *Valvata japonica* is approximately 5 mm in diameter, and there are five and one-half whorls. The shell is smooth, noncarinated, somewhat globose, and yellowish-brown in color. The sculpture is of regular striae and the sutures are solid and well impressed.

Internally, the animal is similar in structural detail to other members of the genus. The hermaphrodite gland occupies the last or apical whorl. The male zone and female zone are segregated. The female germ cells occupy the cortical region and are restricted to the peripheral marginal zone. The male germ cells are located in the acini of the medulla.

In the preliminary examination of this material cytological conditions indicate that the Japanese Valvata also exhibits a type of functional protandry (Fig. 1). In the following diagram maturation stages in the male cells are almost completed and the acini are filled with mature spermatozoa. This is the condition of the gland just before the beginning of the "male phase" in the sexual cycle, a stage which has been already demonstrated in *Valvata tricarinata*. The female germ cells are shown approaching the stage of development when they will soon follow the spermatozoa to the hermaphrodite duct. From the preliminary study it is apparent that atypical spermatogenesis occurs in *Valvata japonica*. The complete course of the process has not been observed at this stage of the study.

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Annular Rings in the Long Bones of Turtles and Their Correlation With Size

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A preliminary study of the cross-sections of the long bones of turtles was undertaken following the suggestion of Dr. A. R. Cahn. The objective in view in this study was to determine whether or not there were annular rings present in these bones, and if so to determine any possible relationship between these rings and the size (or age) of the turtles.

The author is greatly indebted to Dr. A. R. Cahn, University of Illinois, whose helpful suggestions and assistance have made this study possible.

Six turtles, *Chrysemys marginata*, two males and four females were taken from Illinois River at Meredosia, Illinois. These turtles were all of different sizes. From these turtles the two femurs, mandibles and humeri were removed and each bone was cut with a fine-toothed metal saw, so that three cross-sections, 1 mm. in thickness, near the ends of the bones were obtained from each bone. These sections were then dried, after which they were fastened to micro-slides with canada balsam.

After the balsam was thoroughly dry and set the bones were ground down to a desirable thickness for microscopic study. Two methods were employed in the grinding process. For one set a carborundum stone No. 112 was used, and for the other different grades of carborundum powder in the following order Nos. 200, 400 and 600; the finer powders being used as a finishing method. The use of the powders proved to be more satisfactory as they gave more even surfaces rapidly.

Two procedures were then used before a study of the sections was undertaken. Half of the sections were simply washed and left to dry, while the other half were lightly stained with basic fuchsin. Upon examination the unstained sections were found to have a greater contrast of structure. While those that had been stained could be used in this study, it was found that a marked contrast was lacking.

Upon a microscopic examination of the finished slides it was apparent that there were present definite concentric rings. It was also noticed that all of the rings were not of the same thickness nor of the same distance apart. As to the appearance of these rings, they presented a solid, dense annulation against the lighter body of the bone which contained the numerous lacunae. An examination of all the sections demonstrated that the mandibles did not present as clear a picture of the rings as did the humeri and femurs; they were therefore eliminated from the study.

An attempt was next made to count the rings with the objective in view of correlating their number with the size of the turtle. After a study of each section, checking one with the other, a count of the number of rings was established for each bone. It was found that the smaller turtles, hence probably the younger individuals, had fewer rings per bone than the larger turtles. It was noted, however, that there is not a definite, continuous increase in the number of rings with an increase in size of the individual. It is entirely plausible to postulate that the variation in the number of rings

is due to individual differences in growth. The variation in the distances between the rings can likewise be supposed to be due to different environmental conditions and individual nutrition. A difference in sex is also noticed, the males being smaller than the females as a rule.

From this study it is tenable to correlate the number of rings in the long bones with the age of the turtle. The postulation is that the rings are a result of the temporary cessation of growth during hibernation causing the heavy ossification of the bone tissue on the outside edge of the bone. The next years growth would then be laid down on the outside of this annular ring. The variations resulting in the number of rings can therefore be due to individual physiological differences. Also seasonal differences would be likewise shown in much the same way as in the annular rings of woody plants, trees.

SUMMARY

1. A preliminary study of the rings in the long bones of turtles has been made.

2. A correlation of the number of rings in the bones and the size of the turtle has been noted.

3. It has been postulated that the number of rings occuring in the long bones may be used to determine the age of the turtle.

Modifications Induced in the Plumage of *Passer domesticus* (Linnaeus) by Experimental Hyperthyroidism*

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The effect of experimental hyperthyroidism on the plumage of birds has been under investigation over a period of more than twenty years. Moulting, changes in the rate of feather growth, and alterations in feather structure have been reported in a variety of birds. Modifications in the pigmentation of feathers following thyroid administration have been repeatedly described. According to some investigators, the color change is in the direction of loss of pigment, while others find that hyperthyroidism causes increased pigmentation of the plumage. The assumption of female plumage in young males of the domestic fowl fed with thyroid preparations has been described by several investigators. Since Keck found that sexual dimorphism in the plumage of the English sparrow is not controlled by sex hormones, it became of interest to test whether other hormones may produce effects on feather patterns.

The present study was undertaken to examine the possible influence of the thyroid on the pigmentation and sexual dimorphism of sparrow plumage. The effects of hyperthyroidism on regenerating feathers were tested in normal and castrated males and females. In each series, feathers were plucked from selected areas which show definite color patterns. Only one side was deplumed in every case. Since it has been shown that thyroxin administration has no effect on fully developed feathers, the untreated side served as a control. Several days after depluming, thyroxin was administered. In most of the experiments, a water solution of Squibb's crystalline thyroxin was injected into the breast muscle. In two series, Squibb's thyroxin tablets were fed to the birds.

In the first experiment, feathers were plucked from various areas: the crown, side of the head, wing coverts, tail, and wing primaries. Injections were begun three days later. The most striking modifications were produced in the chestnut brown lesser wing coverts of the male sparrow. The regenerated feathers were uniformly slate grey in color, showing no brown coloration. Accordingly, other areas of brown feathers were tested. In every case, the brown feathers were replaced by grey ones.

In order to examine the nature of the pigment modification occurring after thyroxin injection, paraffin sections of feathers from the lesser wing covert of male sparrows were made. The brown melanin granules which crowd the barbs of the normal feather are very sparse in the grey feathers which regenerated after thyroxin administration. The greying of the feather caused by hyperthyroidism is really a loss of brown pigment.

In the next series, a large patch of feathers was plucked from the ventral surface of normal male sparrows. This included a patch of black breast and throat feathers and an area of silver grey belly feathers. The feathers which regenerated after thyroxin injection were all uniformly buffy grey

* Contributions from Knox College Laboratories No. 49.

in color. The color of the regenerated plumage resembles the female type much more closely than the normal male plumage.

An additional effect of the injections appeared in the birds of this group. In the sparrow, the beak of the male is intensely black during the breeding season. At the close of the breeding season, the beak becomes light horn colored. The beak color has been shown to be a reliable index of testicular activity. In the males injected with thyroxin in the fall and early winter, when the beak is normally light in color, the beak became dark. In those injected in the spring and early summer, the black color of the beak was lost prematurely. It appears that hyperthyroidism accelerates the normal sexual cycle, both at the beginning and at the end of the breeding season.

A series of castrated males and ovariotomized females were deplumed and injected as in the normal series. The capons suffer more severely than the normal males in loss of weight and moulting, but the pigment modifications are less marked. Of the eight injected male castrates, only two regenerated definitely grey feathers in the lesser wing coverts. The others showed some brown pigment, in varying degrees from tan edges on the grey feathers to nearly normal chestnut color.

A series of 15 normal male sparrows was used to determine the threshold of reaction to injected crystalline thyroxin. The chestnut brown feathers of the lesser wing coverts were plucked from the left side. Injections were begun three days after depluming. Doses ranging from .02 mg. to 1 mg. of crystalline thyroxin were given at intervals of three days until each bird had received three injections. Amounts below .1 mg. cause no visible modification in normal pigmentation. A barely noticeable change is produced by .1 mg., while .25 mg. effects a definite color modification. A dose of .75 mg. is required for the complete loss of brown pigment. The threshold of reaction to crystalline thyroxin in the English sparrow is approximately .1 mg. per 25 g. of body weight, or 4 mg. per kg. body weight.

In one group of sparrows, Squibb's .8 mg. thyroxin tablets were fed *per os*. Feathers were plucked from representative areas as in the previous groups. Doses ranged from five to 14 tablets. The effects of this treatment were slight and not constant. Even the birds receiving the highest dosage showed only a slight dilution of the normal color. It is evident that thyroxin is much less potent when fed in tablet form than when injected intramuscularly.

Conclusions.—(1) The regenerating plumage of *Passer domesticus* is sensitive to the influence of hyperthyroidism. The most conspicuous modifications in pigmentation occur in the chestnut brown contour feathers of various body regions, and in the black breast feathers. Most of the brown pigment granules which normally color these feathers fail to develop, making the feathers appear slate grey.

(2) The feathers of the light grey belly region of the male, regenerating after thyroxin injection, appear darker than normal.

(3) After thyroxin injection, the regenerating male plumage is modified, at least superficially, in the direction of the female color. The feathers which regenerate in the lesser wing coverts, the breast region, and the belly region resemble the female more than the normal male type. It is possible that the thyroid may be involved in the control of sexual dimorphism in feather pattern.

(4) Capons exhibit more severe general effects than the normal males, but the color of the feathers is modified to a smaller degree.

Visual Cells of a Nocturnal Animal*

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The eyes of a nocturnal animal are of interest morphologically since they show evidences of adjustment to differing environments, also because they show a relative degree of adjustments in different forms.

The retinas of cat, opossum and rat were double embedded in celloidin and paraffin and sectioned at 2, 4, and 6 microns. The usual cytological methods of staining were employed.

The relative number and distribution of the visual cells varies considerably in lower vertebrates. The variation is due to the animal's adjustment to his environment. In birds, the number of cones is much higher than the number of rods. The diurnal reptiles have only cone cells. In nocturnal animals as the bat and mouse, there are only few rudimentary cones present among the rods. Other nocturnal vertebrates such as the shark, ray, certain reptiles, the mole, and monkey have only rod cells.

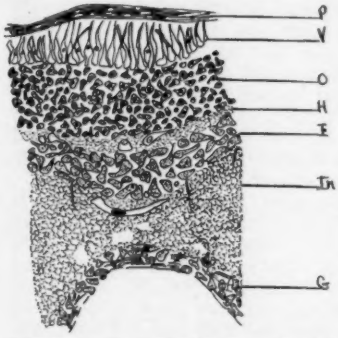

Fig. 1.—Vertical section through rat fovea

P	Pigment epithelium
V	Visual layers, rod and cone cells
O	Outer nuclear layer
H	Henle's fibre layer on outer reticular layer
I	Inner nuclear layer
In	Inner reticular layer
G	Layer of ganglionic cells

In the study of the visual cells, first the rods and cones in the retina of the cat, an animal of nocturnal habits, were studied. The cones were flask or cone-shaped, narrowed at the neck, where the fiber apparatus is situated. The rods are comparatively thick and very granular. There are about three to five rod cells to every cone cell in the cat retina. The cat not only requires rod cells for vision in dim lights, but also cone cells for clear vision of details.

In contrast to the cat, the rod cells of the opossum were very much thinner and filamentous. The opossum has no cone cells because it is an animal of nocturnal habits and requires only rod cells for vision in dim lights.

In the prepared slides of the albino rat, only rod cells could be found toward the center of the retina. Further away, a few rudimentary cones were found interspersed with the rod cells. There are only about five or six rod cells to every cone cell. Toward the periphery of the retina, only rod cells were present. The rods were very thin and filamentous while the cones were conical shaped. However, the cones were less conical than those of the cat, tending to lose their flask shape and to be broad at the lower extremity, narrowing at the top.

* Contributions from the Biological Laboratories of Knox College No. 50.

In the hooded rat, the cones evidenced more of tendency to be thicker at the bottom gradually becoming thinner toward the top. The cone shape is not entirely lost, but it is not as evident as in the cat. The rods are very thin and filamentous with granules interspersed throughout the cell. There are about seven or eight rod cells to every rudimentary cone cell.

In the fovea of the rat, cone cells are found exclusively. They have the same characteristics as the cone cells found in other portions of the rat's eye. They have a broad base and become narrower at the top. They lack the distinct conical shape of the cat cone cells. There are rod cells appearing toward the periphery of the fovea becoming more and more numerous the further away from the center of the fovea. The nuclear layer of the retina thins out slightly in this region. The nuclei of the granular layer, or Henle's fiber layer, broadens towards the center of the fovea. The reticular layer is decreased almost to nothing. The ganglion layer increases at the periphery of the fovea and decreases to one layer at the center of the fovea.

Conclusion:

In reference to the rat, it was concluded that,

(1) The cones are rudimentary as evidenced by their shape—broad at the base and narrower at the top.

(2) The rod cells are highly developed being very thin and filamentous allowing the light and dark rays to be reflected to a greater degree.

(3) There are approximately five rod cells to every cone cell.

(4) There are rudimentary cone cells exclusively in the fovea. There are only rod cells at the periphery of the retina while both rod and cone cells are interspersed in between them.

An Illinois Marsh Willow sawfly (*Amauronematus lineatus*) (Hymen., Tenthredinidae)

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In Illinois there are many species of sawflies which feed on the numerous kinds of willows growing along the edges of rivers and streams. Extensive collecting for several years throughout the state indicates that only one of these, namely, *Amauronematus lineatus*, feeds on the willow found in small marsh and temporary pond situations.

The species occurs commonly in the northern two-thirds of Illinois. It is one of the earliest willow insects to begin active feeding. The adults emerge from about the first of April until the first of May. Egg-laying takes place soon after emergence. The eggs are ovoid, deposited in a slit cut in the lower epidermis of the willow leaves by the saw of the female, and appear as whitish pustules. In the laboratory at room temperature the eggs hatch in six or seven days, but in the field they probably require two to four weeks. This estimate is based upon observations of *Dolerus illini* eggs, which are deposited at the same time as those of *A. lineatus* and may require thirty days for incubation. The larvae feed upon the leaf edges and grow rapidly, becoming full grown in about three weeks. They then form a brown cocoon at the base of the willows and are dormant until the following spring. The entire feeding period is over before the middle of June. From an ecological standpoint the species may be regarded as a vernal predominant of the *Salix humilis consocies*.

This sawfly belongs to the subfamily Nematinae which taxonomically speaking is in a state of confusion. It contains several hundred species differing in a large number of morphological characters that can be well shown only by illustrations. This applies equally to both adults and larvae, and yet very few papers dealing with nearctic species of Nematinae are illustrated. For this reason, the species under discussion is here briefly redescribed to bring out the diagnostic characters of the larvae and adults. The male has not been definitely associated with the female before, so an allotype of this sex is herein designated.

Amauronematus lineatus (Harrington)

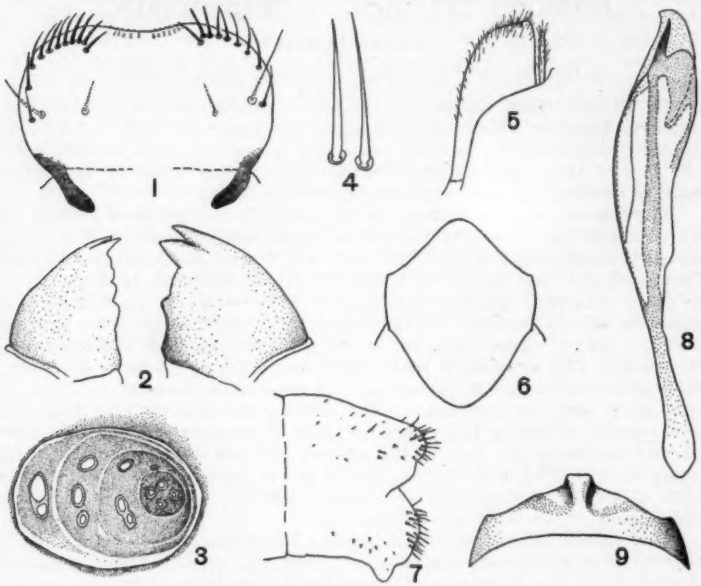
Nematus lineatus Harrington, Can. Ent., vol. 25, no. 3, March, 1893, p. 59, ♀. *Amauronematus lincolnensis* Rohwer, *ibid*, vol. 41, no. 1, Jan., 1909, p. 19, ♀. ***New synonymy.***

Female.—Length 10 mm. Color yellowish brown, with small black areas on dorsum of head and thorax. Dorsum of abdomen with black varying from a narrow, interrupted black line of the meson to an area covering almost the entire dorsum. The species is similar in general appearance to some other species such as *knabi* Rohwer, but may be distinguished from them by the long sheath, fig. 5.

Male.—Length 9 mm. Head and thorax almost entirely black, with brown areas around the eyes, antennae and lateral sutures of thorax. Abdomen with dorsum black and venter mottled with yellowish and blackish

brown. Legs pale yellowish brown, the coxae and upper and lower edges of the femora somewhat suffused with darker brown. Genitalia yellow.

Procidentia (fig. 9) clearly defined, tapering towards base, projecting only slightly beyond apex of segment, the apical portion of the segment excavated on each side of the procidentia. Subgenital plate relatively short, its apex rounded when expanded, fig. 6, but in dried specimens often curled at extreme tip so as to appear slightly emarginate. Genitalia typical of the genus; penis valve as in fig. 8.



EXPLANATION OF FIGURES

Morphological characters of *Amauronematus lineatus:*

Fig. 1.—Epipharynx of larva.
2.—Mandibles of larva, dorsal view.
3.—Antennae of larva.
4.—A larger magnification of apical setae of epipharynx.
5.—Sheath of adult female, lateral view.
6.—Subgenital plate of adult male.
7.—Apical segment of larva, lateral view.
8.—Penis valve of adult male, lateral view.
9.—Procidentia of adult male, dorsal view.

Allotype.—♂; Snyder, Ill., April 14, 1930, coll. Frison and Ross. Deposited in the collection of the Illinois State Natural History Survey.

Larva.—Length when mature, 18 mm. Head and body pale green, the body with a fairly wide grayish band down each side above the spiracles. Diagnostic structural characters as follows: Labrum with four long setae and an irregular pattern of pits. Epipharynx, fig. 1, with a row of nine to twelve setae on each side at the apex. Antennae flat, fig. 3, with one incomplete and two complete rings surrounding the small, slightly raised central disc. The arrangement and size of the sensory openings are quite variable, seldom being exactly alike even in the two antennae of the same individual. Segments 4 to 8 of abdomen with 6 annulets. Apical segment rounded, fig. 7, without projections or paired armature.

Some Interesting Pre-Linnaean Names

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Even the institutions and the practices with which we are most familiar have usually come into existence by gradual processes of development from simple, scarcely recognizable beginnings. This developmental point of view, so common in our evolutionary considerations of biological phenomena, is often lost sight of when we come to consider certain particular realms of thought and practice in science. In the fields of taxonomy and of nomenclature, we are guided by laws and rules and are influenced by opinions expressed by competent authorities, but to the average zoologist there is little tendency to look behind the rules to seek an understanding of their claim to validity. There is even less disposition to search for their origins.

In general, zoologists are more or less familiar with the International Rules of Zoological Nomenclature, formulated by the International Commission as a series of compromises resulting in the crystalization and codification of the practices which had become established among the various peoples whose biologists had been contributing to the field of taxonomy. Since these International Rules state that the Tenth Edition of Linnaeus' Systema Naturae is the work which inaugurated the consistent, general application of binary nomenclature in zoology, most persons fail to look behind this monumental work of 1758 for evidences of the beginnings of the system of naming animals. At least an attitude of tacit acceptance seems to place the system of binomial nomenclature on the level of a miraculous discovery. One does not have to go far in the study of the history of nomenclature to find that this reputed child of Linnaeus' brain did not spring forth as a fully formed concept, perfect in its earliest inception. The mere fact that the Systema Naturae underwent ten editions, over a period of twenty-three years, before a "consistent, general application of the binary nomenclature in Zoology" was attained, gives ample evidence of a development from rather imperfect beginnings. With Linnaeus, the system was at first a concept, imperfectly applied, which took years for a genius to perfect. Many would say that even the concept was not original with the great Swedish naturalist.

Without in any manner reflecting on his personal attainments nor on the justly earned high esteem with which his name is revered, I wish to point out a few evidences of procedure and practice common among naturalists before the day of Linnaeus and to call attention to these as a probable basis for the natural development of a system which it happened to be Linnaeus' good fortune to accept and develop. Activity in any field of endeavor is so diversified that historians, looking on the past, can almost always pick out from the broad stream of contributions, minor currents which in retrospect seem to mark the origin of well defined movements. All too often these relations are accidental and not directly causal. Every great discovery when once attributed to an individual has contenders for the honors. Many of the grounds are merely lucky coincidences and too often vague suggestions assume new significance in the light of new discoveries.

Because indistinct mutterings may become oracular pronouncements to willing ears there are dangers of being branded as iconoclastic when one attempts to depict natural origins for well accepted doctrines.

Without attempting to credit or discredit any individual or group of individuals for the distinction of originating the accepted system of zoological nomenclature, there are facts and evidences tending to show a gradual growth of habit and of form in the application of technical names to organisms. Foremost of these is the fact that Latin was the accepted language of culture. Its utilization as the medium for describing and for naming organisms was but a natural following of a fixed custom. The introduction of a distinctive type face for scientific names was apparently a mechanical rather than an intellectual choice.

As early as 1670 we find instances of utilizing Latin names for organisms even when the text was in another language. The writer has discovered an interesting instance in the Philosophical Transactions of the Royal Society of London. In this pioneer journal of colonial times there are many early narratives of American natural history communicated by prominent colonists back to their colleagues at home. One of these narrations finds particular application here for in volume 5 of the Philosophical Transactions (1670, page 1151) is printed an "Extract of a Letter from John Winthrop, Esq. Governor of Connecticut in New England, to the Editor, concerning some Natural Curiosities of those Parts, especially a strange and curious Fish, sent for the Repository of the R. S." The object of this letter was a basket-star found off the New England coast. Governor Winthrop gave a most thorough though zoologically imperfect description of the animal in English but when he assayed to name it he fell into the Latin as shown in the following quotation: "The fish, as yet nameless, we may call Piscis Echinostellaris Visciformis; its body resembling an echinus or egg-fish, the main branches a star, and the dividing of the branches, the plant mistletoe." The descriptive phrase applied to this animal is just as formal and distinctive a name as many of the earlier names of Linnaeus before he adopted and developed the system of binomial designation.

It is not surprising that out of beginnings such as the foregoing, in common usage, the descriptive words used to designate animals should come to have more definite meaning and form. At least a crudely parallel instance had previously become established before this time in the combination of surname and Christian name for designating human individuals.

Many of Linnaeus' early names were no more regular in formation than Governor Winthrop's formal descriptive name for the basket-star. As one instance we may cite the fact that in the sixth edition of the Systema Naturae (1748) the golden pheasant instead of a binomial name bore the descriptive phrase *Phasinus crista flava, pectore coccineo.* A less striking transformation came in the name of the nine banded armadillo. In the tenth edition this has the truly binomial form *Dasypus novemcinctus* though ten years earlier it bore the descriptive phrase *Dasypus cingulis novem* in the sixth edition.

One of the most difficult things in the realm of nomenclature is the reading of motives into the cold, formal scientific names given by the early authors. Many names which have strictly binomial form seem to be accidental, yet out of accidents such as these nomenclature had its probable origin. In one of the ancient books which I happen to own, Daniel Le Clerc has given a number of name forms which would look well in the tenth edition of Linnaeus but which cannot by any stretch of the imagination be regarded as truly generic and specific names. They seem so very distinctly modern that only the date 1715 on the title page warns one of their

invalidity. Under the centered caption LUMBRICUS LATUS is described a human parasite (page 37) which had been rather frequently mentioned in the older literature under this same name at least back to the year 1609. Though perfect in form this name has no standing because of the canon which rules that binomial nomenclature reached its consistent general application in 1758.

Instances of this type have particular significance as examples of the ruthless way in which Linnaeus misapplied classical names and names in general use since antiquity. Le Clerc followed an ancient usage when he used the name Lumbricus for a tapeworm while Linnaeus for some unknown reason in this as in many other cases used a well authenticated name in a wholly new meaning. Following Linnaeus' error we today continue to use the name Lumbricus as the generic designation of one of the common European earthworms.

In the same book mentioned above Le Clerc (1715) described a tapeworm from cats and dogs (page 212) under the name Taenia canina. He utilized these two words as a centered heading above his description, sharply setting them off in capitals from the descriptive phrase which followed: TAENIA CANINA, *aliique Canum & Felium Vermes.*

Forty-three years later Linnaeus gave this same name, without change, and thereby rendered it a valid generic and specific designation. More recently this species has been transferred to the genus Dipylidium.

The instances of pre-Linnaean names here cited are not unique. They are examples of hundreds of others cited and discussed in the literature on nomenclature. Every branch of zoology has its classical instances that give endless opportunnty for speculation as to the true origin and meaning of binomial nomenclature. C. W. Stiles in his prolific writings and Leonhard Stejneger in his interesting article entitled "A chapter in the history of zoological nomenclature" (1924) have cited numerous instances of names apparently in good form antedating the period of Linnaeus. Some authors go so far as to say that Tournefort and other predecessors of Linnaeus originated the use of the generic name and the generic concept as we now use and understand them. Without taking sides in this discussion as to priority, the writer has attempted to show some of the evidence as to how common, natural usage grew into a system for which Linnaeus is generally and justly accredited as the founder and developer.

The Destruction of Bird Life by Hail

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On Thursday, April 20, 1933, a hailstorm of considerable severity passed through the city of Baton Rouge, Louisiana. Hailstones fell at the Louisiana State University from 8:30 to 8:50 p. m. The hail completely covered the ground, making a field of white that showed up plainly during the intermittent flashes of lightning. From reports made to the Department of Zoology, the path of the storm was estimated to be 50 miles long and 25 miles wide. The intensity of the storm varied in different parts of the area, suggesting alternate light and heavy streaks; Baton Rouge was in the center of one of the heavily beaten areas. The size of the hailstones ranged from that of an average-sized marble to that of a golf ball. Dr. R. J. Russel of the Department of Geology recorded maximum sizes of one and one-half inches in diameter.

One of the significant points about the storm was the simple construction of the hailstones. Ordinarily hail is made up of alternate concentric rings of hard and soft ice, with hard ice at the center. Specimens from this storm contained less than the average number of rings which were of more than average thickness. This construction accounted for the marked softness of the ice and the readiness with which it melted.

Birds in the path of the storm without shelter were either beaten to death or hopelessly crippled. The following casualties were recorded in the vicinity of the university campus:

Scarlet tanagers, *Piranga erythromelas* (males)	27
Cow birds, *Molothrus ater ater*	3
Mocking birds, *Mimus polyglottis polyglottis*	6
Towhees, *Pipilo erythrophthalmus erythrophthalmus*	1
English sparrows, *Passer domesticus domesticus*	7
Cardinals, *Cardinalis cardinalis cardinalis*	3
Woodthrushes, *Hylocichla mustelina*	1
Rose-breasted grosbeaks, *Zeleloidea ludoviciana*	1
Meadow larks, *Sturnella magna magna*	6
Black-billed cuckoos, *coccyzus erythrophthalmus*	3
Red-wing blackbirds, *Agelaius phoeniceus phoeniceus*	3
Red-eyed vireos, *Vireosylva olivacea*	1
Indigo bunting, *Passerina cyanae*	1

Had detailed study been made, the above number of birds affected would have been much greater. As shown by the table a number of scarlet tanagers were taken. These birds are seldom found in this region except when they light to feed during their migratory flight. Other significant points were the presence of the black-billed cuckoo (the first record for this locality), and the rose-breasted grosbeak.

Two men while training a pointer, found twenty-five quail on a five-acre plot of ground near Istrouma, a small town on the outskirts of Baton Rouge. The dead and crippled birds in such a small area furnishes an index to the possible number of birds killed in the thousand square miles covered.

This is the heaviest hail storm known in Baton Rouge in the last fifty years, and although destructive in nature it has permitted collection of valuable scientific information and provides one example of how the balance of nature is accomplished.

A New Species of *Zanchlophorus* From *Cryptobranchus alleganiensis**

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Through the courtesy of Dr. C. G. Huff of the University of Chicago, material of an intestinal parasite from *Cryptobranchus alleganiensis* has been placed at my disposal for study and description. Both male and female specimens are present in the collection and afford the basis for establishing a new species of the genus Zanclophorus and also furnish a second record of the occurrence of this genus in an amphibian host. As in the case of *Zanclophorus cryptobranchi*, these specimens are much smaller than are the species recorded from reptilian hosts, but they show the characteristic well-defined three lips which are bordered internally by a chitinous band and which have the lateral margins of the adjacent lips supported by curved cuticular plates. Each lip bears two prominent papillae. The vestibule is prominent and is heavily cuticularized. The cylindrical esophagus ends in a double bulb, the posterior portion of which is greatly enlarged and provided with cutting plates. The cardia are also cuticularized. The tail of the male (Fig. 7) shows five pairs of post-anal papillae; two lateral and three sub-ventral in position. There are also two pairs of ad-anal and three pairs of pre-anal papillae in addition to a single median pre-cloacal papillus. A pre-anal sucker and well-developed ventral muscle bands are also found. The spicules are sub-equal, slender, and slightly flanged. The accessory piece is well-defined, although but poorly cuticularized. The vulva in the female opens in the posterior fourth of the body. The opposed uteri contain 1- to 2-celled embryos; this form like the other species from Cryptobranchus being apparently oviparous.

The average measurements are as follows:

Male:—Body length, 6-7 mm.; greatest thickness, 0.25-0.28 mm.; length of vestibule, 0.115-0.125 mm.; length of esophagus, 1.15-1.22 mm.; diameter of anterior bulb, 0.175-0.182 mm.; measurements of posterior bulb, 0.165-0.17 mm. by 0.185-0.195 mm.; nerve-ring, 0.45-0.48 mm. from the lips; excretory pore, 0.85-0.95 mm. from the lips; cloacal-tail distance, 0.35-0.4 mm.; sucker-cloacal distance, 1.15-1.22 mm.; spicule measurement, 0.75-0.76 mm.; accessory piece length, 0.08-0.082 mm.

Female:—Body length, 7-8 mm.; thickness at vulva, 0.3-0.32 mm.; length of vestibule, 0.12-0.125 mm.; length of esophagus, 1.2-1.22 mm.; diameter of anterior bulb, 0.16-0.17 mm.; measurements of posterior bulb, 0.175-0.18 mm. by 0.19-0.2 mm.; nerve-ring, 0.52-0.55 mm. from the lips; excretory pore, 0.92-0.945 mm. from the lips; vulva-anus distance, 1.8-2 mm.; anus-tail distance, 0.36-0.42 mm.; segmenting ova measure 0.06 mm. by 0.12 mm. as they enter the ovejector.

The general characteristics are such as to place these forms in the genus Zanclophorus. While the size and relative position of the various structures separate them from the other species of the genus, the most striking characteristic is that of the variability of the cuticular plates which support the lips. The usual position of these plates is along the adjoining margins of the lips in the form of "U-shaped" structures (Figs. 1a, 1b). Some of the specimens show considerable variance from this plan of struc-

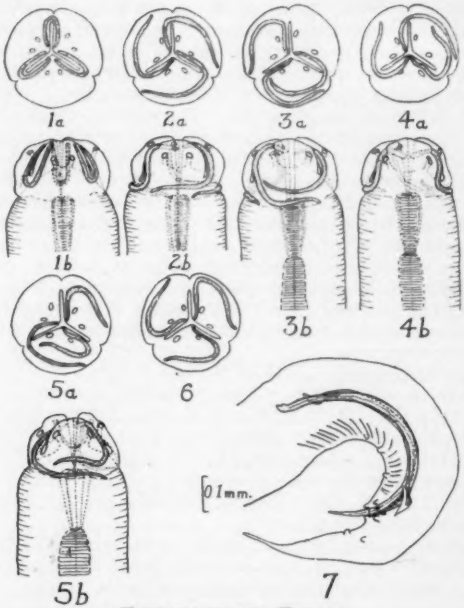
* Contributions from the Biological Laboratories of Knox College No. 51.

ture (Figs. 2a, 2b, 3a, 3b, 4a, 4b, 5a, 5b, 6), the "U-shape" giving way to a number of other forms, usually because one of the legs of the "U" fails to curve up the side of the adjacent lip. Sometimes the variation is symmetrical either to the right or to the left. In other cases the lips show asymmetrical placing of the plates. In all of these variations there is a support along the base of at least two of the lips somewhat similar to the one found in *Spironoura cryptobranchi*. It seems that this form is showing definite transitional stages between the basal bar of the lips of some Spironourids and the "U-shaped" lateral bars of the lips of *Zanclophorus cryptobranchi*, thus affording another link connecting these two genera of the Family Kathlaniidae.

Because of this striking variabiilty, the species is named *Zanclophorus variabilis* n. sp.

The type host is *Cryptobranchus alleganiensis*.

The type material is in the Helminthological Collection of the U. S. National Museum.



EXPLANATION OF FIGURES

Figs. 1a, 2a, 3a, 4a, 5a, 6. *Zanclophorus variabilis.* End views of heads of different specimens showing variations in the arrangement of the cuticular lip supports.

Figs. 1b, 2b, 3b, 4b, 5b. Lateral views of same heads shown in 1a, 2a, 3a, 4a, 5a.

Fig. 7. *Zanclophorus variabilis.* Lateral view of tail of male.

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